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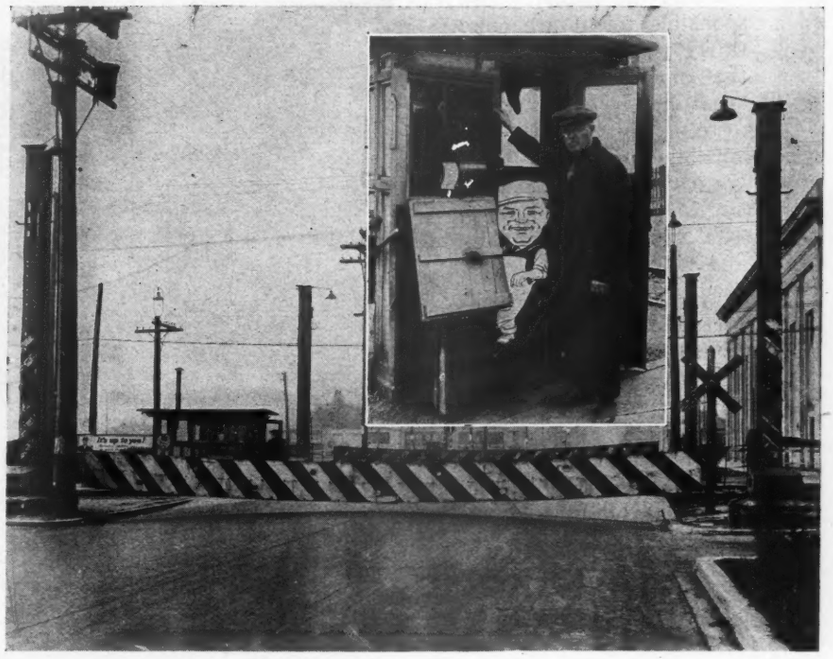
Here Is Some Good Service Evidence

On the Operation of Knife-blade Switches that Shows How Much Abuse They Will Stand



ACTUAL service is the final test which all apparatus must stand. It is the qualified judge of satisfaction and the starter for some prolonged arguments on ought-to-be and should-be theoretical operations with the practical man on one side and the technical expert on the other. Usually there is a compromise and something good comes out of it after all.

If you readers want to start such an argument here is a good chance. What will be the useful life of a knife-blade switch that is operated continuously every three to six minutes, without replacement of parts, in starting and stopping a 3-hp. motor?

The following letter which I recently received from J. E. McNeil of the Square D Company furnishes a starting point. He says:

"After reading the article in a recent issue on old motors which have withstood years of service I thought you might be interested in the following record achievement of safety switches.

"The other day I received a letter from Chicago telling me about four Square D switches that are used on the motors that raise and lower the gates at the Austin Boulevard crossing of the Douglas Park Branch of the Metropolitan West Side Elevated Railway Company in Chicago.

"The letter stated that these switches are operated twice every three to six minutes a day in raising and lowering the gates. They have been in service about two years and on the basis of operating an average of 500 times daily have successfully withstood the severe service of more than 350,000 operations. Frank Novotny, who wrote the letter says that they are still in good mechanical condition and working very satisfactorily. From all appearances they will stand many more operations before beginning to show signs of wear."

I don't want to spoil the chance of any one having his say on this subject nor do I want to put Mr. McNeil in the position of bragging about this performance. He didn't —he has simply furnished some information on switch operation that is mighty interesting and if any one else has other or additional service records I think he will be as glad to know about them as I am.

Incidentally, I might say that I went out to see this installation, since it is near our editorial office, and the pulling and closing those switches get is aplenty and would satisfy the greed of anyone who would like to try to wear out a switch in service. Yet they are still in good condition just as Mr. Novotny has pointed out.

The four switches are connected in the circuits of four variable speed, three-phase, 60-cycle 220-volt induction motors each of which is rated at 2.8 hp. These motors are located in sheet iron housings at the base of the supporting columns for the gates shown in the above photograph. They are protected by ITE circuit breakers, and limit switches.

Now then, if you have a switch installation in your works that has stood more abuse than these in two years, send me the details and a good picture. I'm making a collection of this sort of service evidence.

Practical Pete

A Glimpse Into the Works of

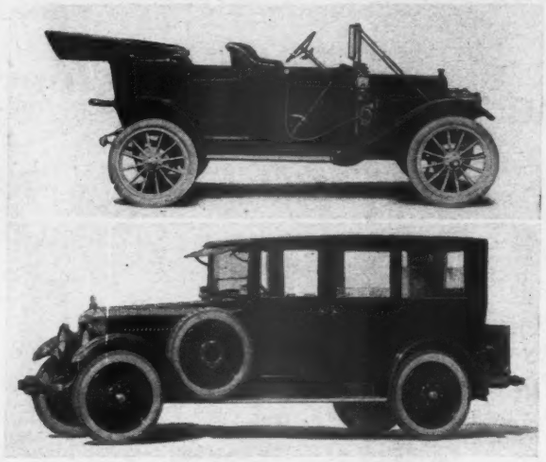
The Studebaker Corporation of America

Where mass production and progressive assembly of the automobile have been an outgrowth of the carriage and wagon industry. The seventh of a series devoted to the growth and extent of our basic American industries.

THE AUTOMOBILE and the industry responsible for it are only thirty years old. During that time they have developed until now, according to the census of 1919, automobile manufacturing is our third largest industry. In 1922 approximately 2,340,000 passenger cars and 260,000 trucks were produced in the United States. Nor has the development been in the extension of manufacturing facilities alone. The "horseless carriages" of 25 to 30 years ago were extremely unreliable. Those who had the courage to try them never knew when they were going to stop. The automobile of today is probably as reliable as any other piece of equipment in common usage, not excepting many devices which are less complicated mechanically, and this reliability exists irrespective of the degree of mechanical ability or lack of ability of the driver. Along with this mechanical improvement has come a refinement in appearance and comfort. The uses to which automobiles are put are so varied that often it is a point of argument as to whether an automobile is a vehicle for pleasure or for business.

Probably the best indication of the growth of this industry is shown by the census report on number of wage earners. In 1899, about 2,000 wage earners were employed by the automobile, body and related industries. By 1904 these had grown to 12,000 workers; by 1909, to 76,000; to 127,000 in 1914 and to 343,000 in 1919, thus making it the seventh industry according to the total number of wage earners employed. Automobile manufacturers were responsible in 1919 for production to the value of $3,080,000,000. Of this, the cost of material is about 63 per cent of the total value of the manufactured product. This is in considerable contrast to the flour milling and packing industries, which were mentioned in previous issues, where the value of the raw material was between 80 to 90 per cent of the total value of the finished product.

In the early days of the automobile industry, an effort was made to put a gasoline engine into a buggy and for a number of years the design of the buggy was closely followed in the manufacture of automobiles. This naturally led many buggy and wagon manufacturers to enter in the automobile field. One of the most



How the car of 1910 looks alongside one of today.

Many refinements in appearance, construction and reliability have been made in automobiles in the past ten or fifteen years. Many readers will remember older cars.

Plants No. 1, in the foreground, and No. 2, in the distant background, of the Studebaker Corporation at South Bend, Ind.

These two main plants of the Studebaker Corporation cover 150 acres with a floor space of 4,875,000 sq. ft. Plant No. 2 is the more modern and alone covers an area of over 100 acres. Altogether, the plants of the Studebaker Corporation, including those in Detroit, cover 225 acres, contain 7,100,000 sq. ft. of floor space, and have a capacity of 150,000 automobiles per year. Originally, the South Bend Works was a carriage and wagon factory. This part of the business has been disposed of and now the entire energy of the organization is devoted to the construction of passenger-car-type automobiles.

The Studebaker Corporation dates its beginning from an enterprising, country blacksmith shop.

In 1852, two Studebaker brothers began the manufacture of wagons along with their blacksmithing. Their first office is shown at the right. By 1868 they were doing a $350,000 business annually and soon became one of the most prominent wagon and carriage manufacturers. In 1910 they bought a Detroit automobile factory and since then their organization has occupied a prominent position in the manufacture of gasoline cars. Four of the Detroit factories are shown in the accompanying illustrations. However, a large portion of the later developments and extensions of the organization has been at the South Bend Works.

prominent of these was the Studebaker Brothers Manufacturing Company, which is now known as The Studebaker Corporation. Approximately 71 years ago, in 1852, at South Bend, Ind., H. and C. Studebaker, blacksmiths and wagon makers, began business with a capital of $68 and two forges. Later three other brothers joined the business which in 1863 was incorporated as Studebaker Brothers Manufacturing Company, with over $200,000 assets. At that time its sales averaged about $350,000 annually.

For many years, Studebakers were one of the largest producers of horse-drawn vehicles. They were attracted early to the possibilities of the automobile industry for in 1897, according to the minutes of a board meeting, $2,000 was appropriated for building and experimenting with a "horseless vehicle." In 1902 the company actually launched into the building of electric runabouts and trucks, a business which it continued until 1912. About 1904 it began building, in connection with another company, gasoline-propelled automobiles known as the "Studebaker-Garford" cars. In 1910 it purchased an automobile company in Detroit and became a manufacturer of gasoline cars.

The Studebaker Corporation, organized in 1911, was the consolidation of this Detroit com-

Automobile factories are one of our best examples of specialized production, as shown here.

It was early found, that if mass production was to be feasible, some mechanical method of getting the work to the machine and away from it was necessary. It would require a small army of men to handle the material which the conveyors carry smoothly, and always to the proper destination. The upper illustration shows motors undergoing block tests. The illustration below shows a battery of gear-cutting machines.

Some of the steps in the construction of automobile bodies.

The wooden framework for closed bodies is assembled in the jig or frame shown at the right, above. This holds the parts in perfect alignment while they are fastened and glued together so that the upholstery and trimmings may be cut beforehand to fit. Conveyors carry the frames away as shown in the lower illustration and as they travel along they are painted and the fittings and finally the upholstering attached, as is shown in the illustration at the left. Here the space overhead is used by a belt conveyor for handling other material.

pany and the Studebaker Brothers Manufacturing Company. This new organization proceeded to operate the Detroit plant for automobile production and the South Bend plant for horse-drawn vehicle production. The horse-drawn vehicle business was disposed of in 1919 and 1920 and at present the corporation confines itself to the manufacture of passenger-car automobiles only.

During 1922 the company sold over 110,000 cars, or an average operating capacity of about 430 cars per day. Plant extensions were completed in 1922 which increased the plant capacity to approximately 600 cars per day, or over 150,000 annually. The plant and property investment is over $45,000,000 and the company employed during the past year an average of 17,663 workers, or about 4,600 more than the previous year. An evidence of the growth of this concern as well as the industry is shown in the fact that about half of the floor space and about 75 per cent of the machinery and tool equipment has been added within the past six years. In addition, older buildings have been modernized as far as possible by the addition of new equipment and methods.

Of particular interest are the special plans used by Studebaker in its relations with employees. In spite of the large increase in the number of employees, approximately two-thirds receive anniversary checks denoting a period of service longer than one year. Also, over one-third of the factory employees receive vacations with pay, which show that they have been employees for more than two years. Also, over 3,000 employees are purchasing or own stock in the Studebaker Corporation.

Another outgrowth of the automobile industry has been extensive improvements in manufacturing methods, especially along the lines of specialization of machines and tools, many of them automatic or semi-automatic, often to perform only a single operation. The result has been intensive production of interchangeable parts. Also the industry is an extensive user of conveyors both for manufacturing and assembly. The benefits of these developments have been shared by many other industries.

These illustrate two of the steps in the final assembly of the car.

Wheels, tank, fenders, headlights and the other miscellaneous small parts of a car are put upon a stock rack in the stock room, as shown in the illustration at the left. Each rack contains the parts for one car. The racks are carried on conveyors to the assembly lines, as shown in the illustration at the right, and alternate with the chassis on the assembly conveyor. The parts are taken as needed from this stock rack and assembled on the car. The conveyor moves forward so as to bring the car to the different assemblers in succession, each specializing on placing a specific part on the car.

BESIDES TELLING just how to test alternating-current motors, this article shows what is to be gained by such tests. Such tests will detect loss of power by defective equipment, misapplied equipment and low power factor. They will show up the faults of obsolete equipment. They will give the accounting department a definite basis on which to distribute costs. Tests should be made when new machinery is being installed and when additions or subtractions are made in group drives.

Directions for

Making Motor Tests

And Some Reasons Why They Should Be Made Regularly and at Certain Times

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Ore Company, East St. Louis, Ill.

IN THE industrial plant, the necessity of motor testing has been more and more recognized during the past few years and should now become of still greater importance under the spur of increasing needs for economy. The insistent demand of central stations for better power factor conditions associated with industrial loads requires an intelligent study of the duty cycles of motor drives and this study assumes equal importance in connection with an isolated generating station supplying an industrial load. The capacity and voltage regulation of the generators is greatly impaired by low power factors to say nothing of the overburdening of the cables, switches and transformers with excessive wattless current. Here the economic loss occurs in the form of excessive demand charges or in the expense of apparatus to correct the low power factor and poor voltage regulation.

Fig. 1 — Instruments connected ready to make a motor test.
This shows a graphic wattmeter, an ammeter and a voltmeter connected up with current transformers for testing an alternating-current motor. The ammeter and voltmeter have been tipped on their sides only to show them better while the photograph is being taken.

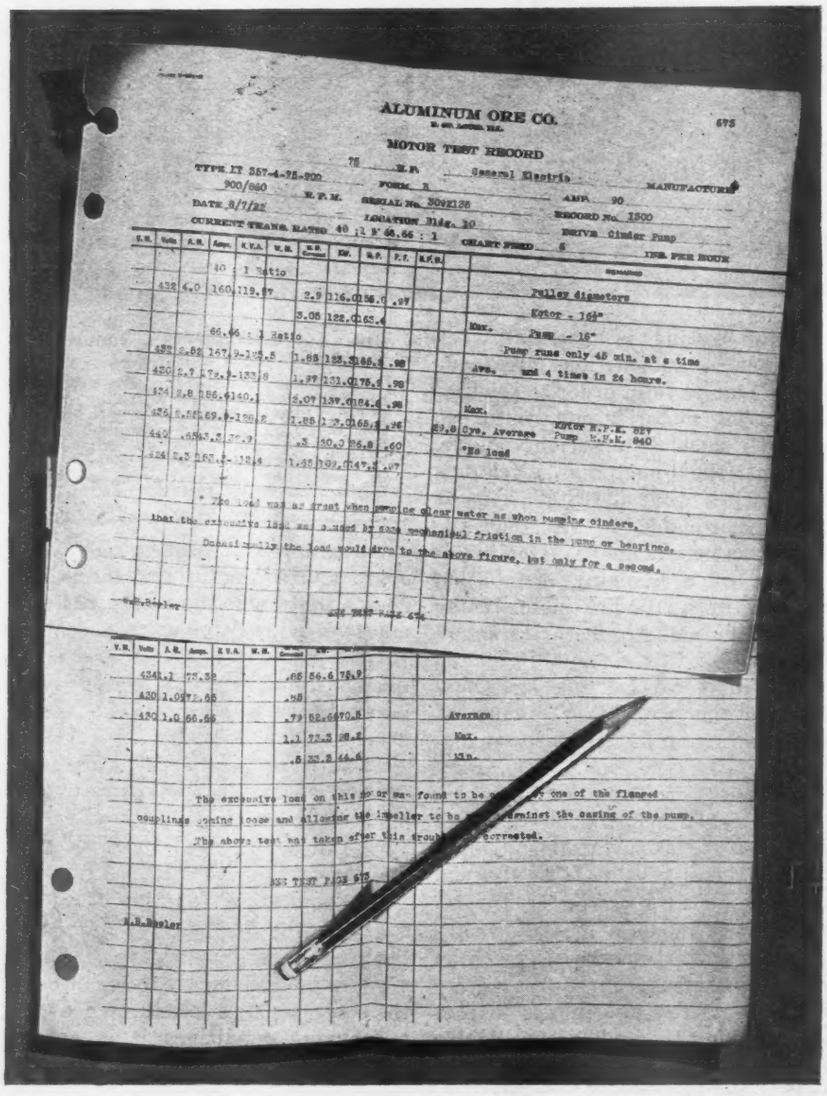
Motor testing is essential when additions or subtractions are made on a group drive in order to see that the driving motor is not overloaded or underloaded to a serious degree. In centrifugal-pumping operations it is essential that all installations be tested thoroughly to see that the duty cycle is economical. One investigation of a pumping installation resulted in a 100-hp. motor being replaced by a 40-hp. motor as actual operating conditions showed that the 100-hp. unit carried full load only half the time. Another pump was installed having a slightly lower discharge head and smaller capacity and driven by a 40-hp. motor which operated at a point near full load continuously. Many water-pumping systems having a variable demand can be handled similarly by the installation of moderate storage facilities. Many instances have been found where men in the operating departments run two pumps in parallel thinking they will secure double output from the pumps. Usually the extra pump is designed only as a spare and a test of the single and double units will show that the output is increased only 5 per cent or 10 per cent while the motor load is increased 60 per cent to 75 per cent. Many other studies of the motor drives in an industrial plant will yield interesting and profitable data concerning the economical operation of production machinery affecting both the quality and speed of production.

One important function of motor testing enters in the selection of motors for new applications. While very reliable data are furnished by the equipment manufacturers, owing to varying conditions it is always best to rely on individual data ob-

tained first-hand. This is particularly true where many duplications of drives occur and the losses due to improper selection of motors are multiplied. Accurate motor tests are essential in choosing between direct-current motors and alternating-current slip-ring motors for variable-speed drives. The measurements of load variations may be used in determining whether to use armature control or field control or a combination of the two, and in selecting the proper slip-ring resistance. In the application of 50-deg. C. temperature rise motors, tests are indispensable owing to the fact that no allowance is made in the motor for temporary overloads which are likely to be encountered on many motor drives as variations in products are encountered or as the mechanical conditions of the driven machinery change. These are points which are liable to be overlooked.

The true measure of a plant's efficiency in the last analysis becomes the cost per unit of production and any variation in costs showing an upward tendency must be traced to some particular department where it then becomes necessary to make a detailed investigation. Here the motor test becomes very important. From the data obtained by a test the machines running under abnormal conditions may be spotted. In this way it is possible to find the motors that have broken-down rotors, or are overloaded from the poor mechanical condition of the drive or those which are supplied by a circuit which is overloaded and gives an excessive voltage drop, and so on. In the light of the knowledge obtained steps may be taken to bring conditions back to normal or even to improve previous practice.

Much test data concerning new methods in production must be obtained in order that the cost department may report on all changes in methods relative to the increase or decrease in costs resulting from such changes. Special reports are usually made to the cost department covering all data as to power consumed, quantities of work handled and other information necessary for a comparison with any other method of accomplishing the same result. Motor tests of old equipment may be compared with tests obtained upon new types of equipment and a program for scrapping obsolete equipment may be based on such comparative tests which prove the economic necessity for the change. The weeding out of obsolete mechanical drives involves consideration of both the electrical and the mechanical forces. In many plants time-study tests are essential to maintenance of a given schedule or for improvement of output and not infrequently this data should be supplemented by motor and circuit tests. These often confirm time studies or themselves may indicate the necessity of closer supervision over certain production processes.


ALUMINUM ORE CO. 675

MOTOR TEST RECORD

TYPE IT 357-4-25-900/860 H.P. 75 General Electric MANUFACTURER

DATE 3/7/22 H.P.M. SERIAL No. 309E126 FORM B AMP. 90

CURRENT TRANS. RATED 40 : 1 & 60-66 : 1 LOCATION Bldg. 30 RECORD No. 1500

CHART FEED 6 DRIVE Cinder Pump

INS. PER HOUR

R.M.	Volts	A.M.	Amps.	K.V.A.	W.M.	M.M. Constant	KW.	H.P.	P.F.	R.P.M.	REMARKS
			40 : 1 Ratio								
432	4.0	160	119.47		2.9	116.0	155.6	.97			Puller diameters
					3.05	122.0	163.4				Rotor - 16½"
			66.66 : 1 Ratio							Max.	Impr. - 16"
432	2.62	167	9-105.5		1.85	122.2	166.8	.98			Pump runs only 45 min. at a time
430	2.7	174	9-133.8		1.97	131.0	178.8	.98		Ave.	and 4 times in 24 hours.
434	2.8	186	140.1		2.07	139.0	184.6	.98			
426	2.55	169	9-126.2		1.85	123.0	165.1	.96	29.8	Cyc. Average	Rotor H.P.M. 827
440	.85	43.2	30.9		.3	20.0	26.8	.60			Pump H.P.M. 860
424	2.3	152	9-124		1.35	109.0	147.3	.97			*No load

* The load was as great when pumping clear water as when pumping cinders, that the excessive load was caused by some mechanical friction in the pump or bearings. Doubtless only the load would drop to the above figure, but only for a second.

Puller

R.M.	Volts	A.M.	Amps.	K.V.A.	W.M.	M.M. Constant	KW.	H.P.	P.F.	R.P.M.	REMARKS
434.1		77.3			.65	56.6	75.9				
430	1.0	72.6			.55						
430	1.0	66.6			.79	62.6	670.8			Average	
					1.1	72.5	98.6			Max.	
					.6	53.8	44.6			Min.	

The excessive load on this test was found to be caused by one of the flanged couplings coming loose and allowing the impeller to be drawn against the casing of the pump. The above test was taken after this trouble was corrected.

Puller

Fig. 2—Forms for recording data taken on a motor test.

These sheets measure 9¼x12 in. and they are filed according to the test number in a loose-leaf binder. The test number is written in the upper right-hand corner. Two important records kept by these forms are the original meter readings and the current-transformer ratio. Sheet 673, shown at the top of this illustration, records a test made on a pump motor which was overheating. The test showed that the 75-hp. motor was carrying over 200 per cent load. The trouble was found to be a defective coupling. After this was replaced the motor ran at an average load of 70 hp. as shown on sheet 674 (the lower sheet). The charts in Fig. 6 were taken on these tests.

Why Not a Physical Testing Laboratory?

The consideration of production studies brings us into the study of the quality and quantity of production. Here motor testing indicates the need of a physical laboratory consisting of mechanical, chemical, metallurgical engineers, or engineers of such other branches as the material produced would require. In such a case the electrical engineers should co-operate with the staff of the physical laboratory in making tests upon production apparatus. It appears that such a method would react towards maintaining a uniform quality of product and insure the maximum output of every unit in the plant. Undoubtedly the greatest benefit of this system would be derived by a very large establishment. However, in the smaller plants a similar method may be followed by combining several of these functions in a few individuals. This

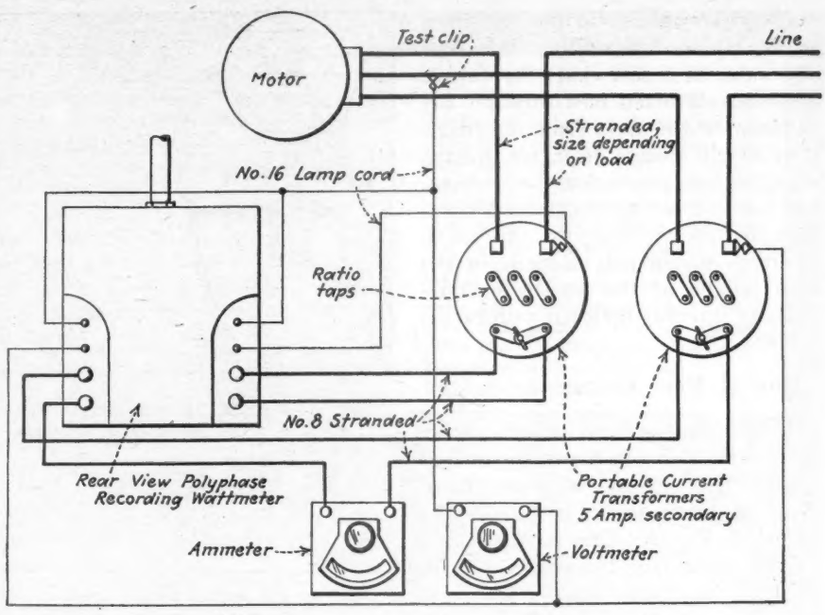


Fig. 4—Connections for making a test on an alternating-current motor.

The current leads and the potential leads attached to the same phase of the circuit must go to the same element of the wattmeter.

system has only been approximated in the writer's experience but the results obtained in a few instances where co-ordinated tests were made indicated great possibilities for the development of some sort of a physical laboratory for making periodic tests on every production unit.

Influence of Periodic Testing on Plant Maintenance

Wherever possible a periodic check of the kilowatt load of each motor in service should be made. By this plan irregularities in the operation of equipment may be discovered before serious consequences are experienced. Quite often centrifugal pumps become unbalanced creating a heavy thrust to one side of the pump and increasing the motor load to a dangerous point. The same condition is often found in the bearings of very heavy machinery. A seasonal variation of load is sometimes encountered on machinery in exposed locations. During the winter months a motor test will sometimes indicate a dangerous overload condition while the summer load is well within the capacity of the motor. The value of a test of this nature is that changes may be made in the nature of lubricant used which will reduce the load to a point within the capacity of the motor and show an appreciable saving in the power used.

Routine tests should always be supplemented by the observation of the oilers or department operators concerning any unusual temperature rise of the stator or bearings. Upon receipt of a report indicating a distressed motor an emergency test should be made immediately to ascertain whether the trouble is in the motor or in the mechanical equipment. If the trouble is mechanical a load test is essential after the mechanical repairs are completed. Many instances have been noted where several motors in a group would be reported as running hot which indicated without necessity of a motor test that a feeder circuit was operating single-phase. Sometimes, however, a single-phase condition like this will not be discovered until a routine motor test is made because if the motors are large and not heavily loaded and all motors on one circuit are shut down at one time no indication of distress will be evident.

Fig. 3—Strip charts clipped to a card for handy filing.

Testing Equipment Required

For the industrial plant having 10,000 hp. or less in connected load and using alternating current the following list of equipment constitutes the minimum for satisfactory motor or circuit testing:

- Two portable current transformers, range 25 to 100 amp. primary, 5 amp. secondary.
- Two portable current transformers, range 200 to 1000 amp. primary, 5 amp. secondary. To be of the through type of single-turn primary.
- One voltmeter, indicating, 0/150, 0/300, 0/600-volt scales.
- One ammeter, indicating, 0/5-amp. scale.
- One wattmeter, polyphase, recording, strip-chart type with device to change speed of chart from inches per hour to inches per minute.

The strip-chart meter has been adopted almost universally for motor tests because of the legibility of the record and the ability to get satisfactory records of any type of intermittent load by varying the chart speed so as not to overlap the fluctuations of the pen.

For ordinary load tests on motors, two observers are required. One man cannot make a simultaneous reading of the wattmeter, ammeter and voltmeter. During a test the voltmeter and ammeter readings should be noted on the strip chart at intervals so that variations in the wattmeter record are noted in connection with voltage and amperage at that instant. Every chart should have indicated on it the date of test, the name of the drive tested, the cur-

rent-transformer ratio and the times of beginning and ending the test. The value of a test chart for future reference is often lost through the omission of this data from the chart. It is nearly always desirable to have a calibration curve for the wattmeter for correcting the actual readings before writing up the tests. Changes should not be made in the zero setting of the wattmeter during the interval between calibration tests.

How to Keep Records of Tests

It is desirable to write up all tests on a form sheet in order to prevent the omission of any necessary data. A good form for this purpose is shown in Fig. 2. This record should include space for the original readings of the meter scale as well as spaces for the actual quantities after the readings have been corrected and multiplied by the instrument ratio. Space should be provided for any desired calculated data such as kva. and power factor and also speed of the motor, frequency, etc. Ample space should be allowed for remarks concerning conditions under which the tests were made, variations in load and observations of pressures, quantities of material handled, speed of belted shafts and observations covering the mechanical condition of drives, the temperature of the surrounding air and of the motor.

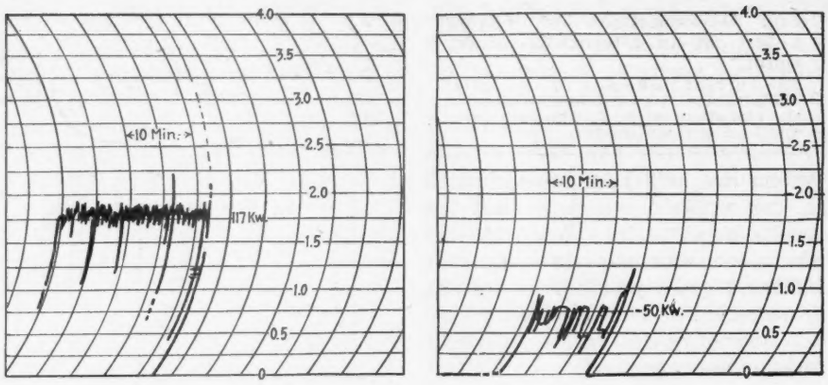


Fig. 6—Graphic meter charts before and after removing trouble on pump.
In Fig. 2 are complete records of the tests during which these charts were taken. The charts show not only the magnitude of the load but also how it varies from time to time.

Every effort should be made to secure sufficient data for properly interpreting the results of the test at any future date. Insufficient data is a common fault of a majority of motor tests. All data which is taken in note books should be transcribed to the form sheet on the day of the test as any omission of data may be more easily supplied while the conditions of the test are still well in mind. Where an index is maintained covering each motor in the plant and an index for each drive, it is desirable to note the average load, date of test, and page number of the form sheet data on the corresponding motor card and drive card. The form sheets called the "Motor Test Record" should be kept in a binder and each page numbered consecutively. Each strip chart corresponding to a record sheet should be given the same number. These strip charts may be filed for future reference in a convenient manner by rolling them up and fastening each end to a 4-in. x 6-in. index card by means of a paper clip as shown in Fig. 3. About five of these charts can be attached to each card and the chart number should be written on the outside. In this manner a large number of strip charts may be fastened on a small card and filed in a regular card-index drawer. The charts are then always immediately at hand for reference.

Connecting the Instruments for Motor Tests

In making tests on three-phase motors using the standard three-phase recording wattmeter, it is necessary to insert two current transformers in the leads supplying current to the motor. Voltage connections, however, must be made to each of the three leads in three-phase testing. The voltage or potential lead from the motor lead which does not have a current transformer, is a common lead between the two potential coils in the wattmeter. In making wattmeter connections it must be remembered that each potential coil must be supplied from the lead which *(Continued on page 371)*

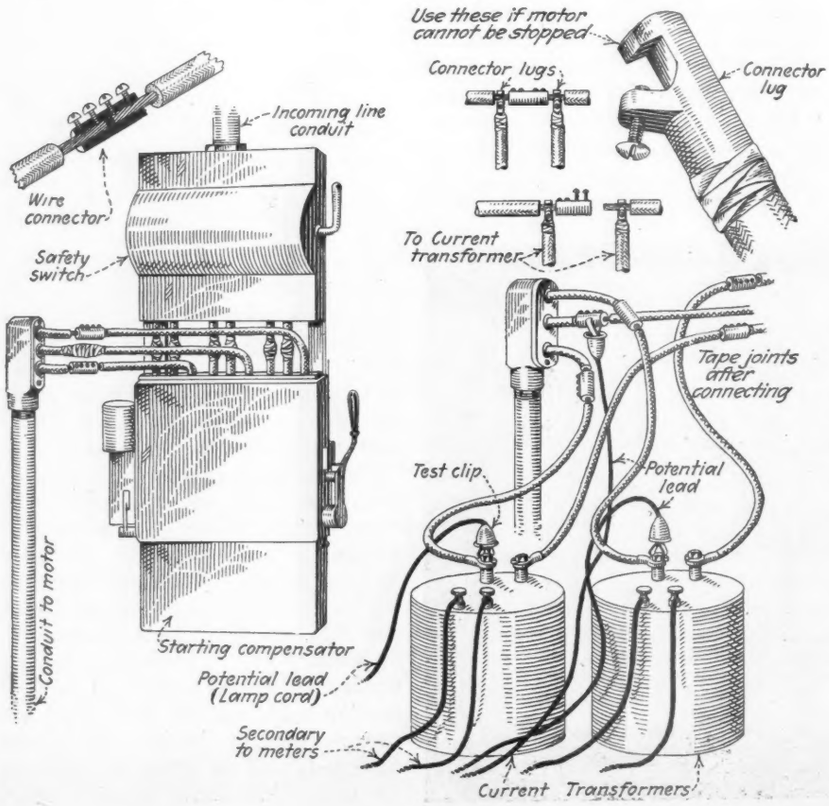
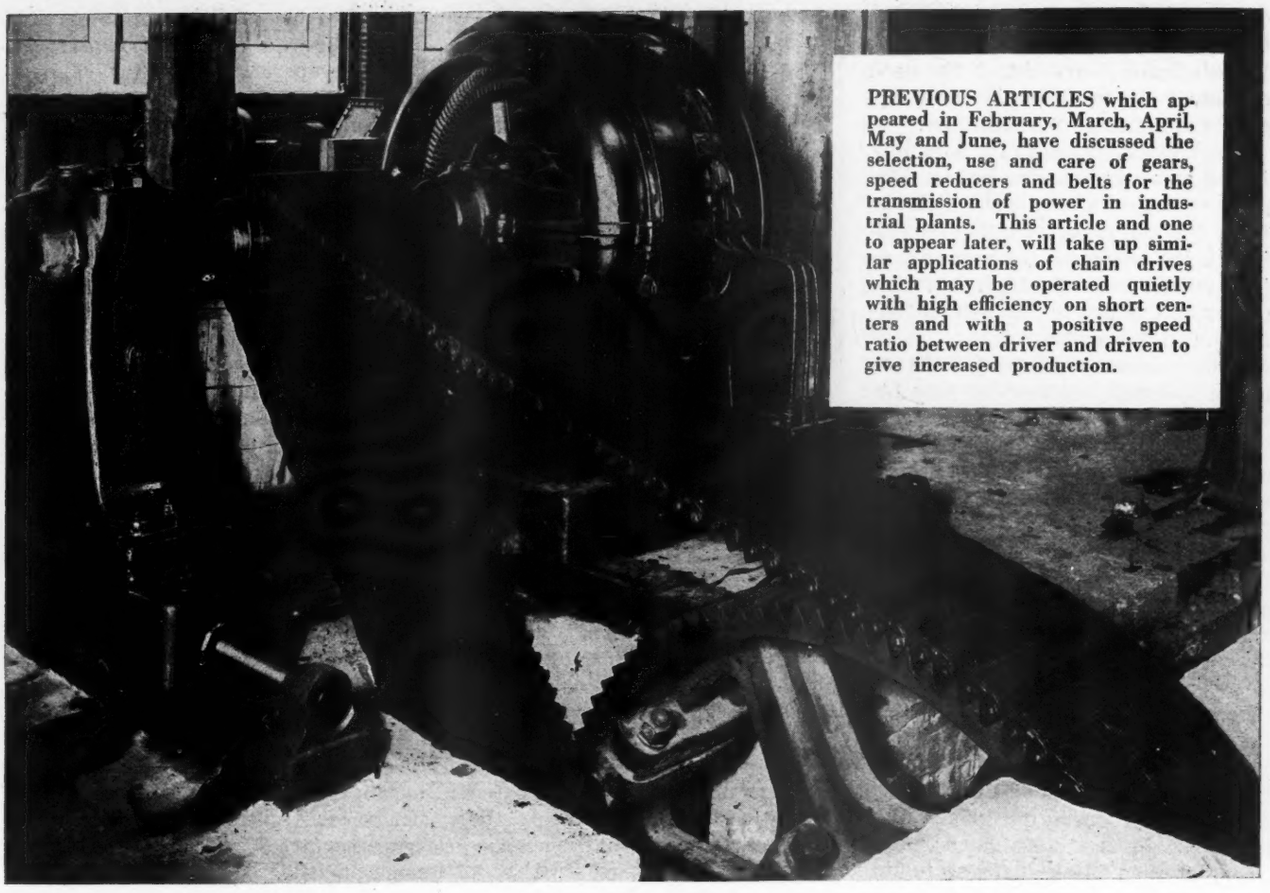


Fig 5—This shows how the leads are connected on a motor test.
When the motor was installed brass connectors were inserted in the leads between compensator and motor. These are opened and the primary of the current transformers is connected in each outside line. If the motor cannot be stopped for making connections, the current transformers may be connected in as shown in the upper right-hand corner. The connecting lugs on the transformer leads are attached on each side of the brass connectors after which these connectors are opened.



PREVIOUS ARTICLES which appeared in February, March, April, May and June, have discussed the selection, use and care of gears, speed reducers and belts for the transmission of power in industrial plants. This article and one to appear later, will take up similar applications of chain drives which may be operated quietly with high efficiency on short centers and with a positive speed ratio between driver and driven to give increased production.

This 300-hp. motor is connected by chain drive to a lineshaft operating a group of rubber mills.

Points to Consider in Using Various

Types and Kinds of Chain Drives

To Provide a Short-Center Connection With the Lowest Possible Power Loss

By FRANK E. GOODING

Associate Editor, Industrial Engineer

CHAIN DRIVES combine many of the advantages and characteristics of belts and gears, both of which have been discussed in previous articles in INDUSTRIAL ENGINEER. Chain drives are used in practically all industries that use power. Their principal advantage lies in their high efficiency; a chain drive will transmit to the driven shaft over 98 per cent of the power delivered to it by the driver. There can be no slip or loss of power nor is there any back lash or chatter. As a silent chain wears it does not lose its efficiency, as the chain gradually mounts the teeth of the sprocket to take up the wear in the joints.

Other advantages to be derived are that chain drives can be operated on short centers, thus saving space and at the same time permit of a much greater flexibility of centers than is possible with a gear drive and they will operate under conditions that interfere with the effective operation of belts, such as heat, cold, wet or greasy surroundings. Next to a belt silent chain drives are the most quiet in operation of any method of power transmission, with the exception, of course, of a direct connection. One of the main advantages is a fixed speed ratio between the driver and the driven sprockets such as is otherwise obtained only through gearing.

With chain drives it is usually possible to operate without idlers. However, they are sometimes used to lead the chain around obstructions or when there is considerable distance between centers. Properly designed and lubricated chain drives operate quietly, but if neglected or if some of the limitations, as speed, size of sprocket, revolutions per minute, pitch and other factors which will be mentioned later, are exceeded life and quiet operation are sacrificed accordingly.

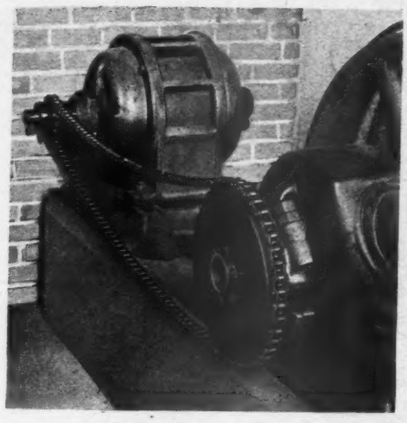
In general, there are three kinds of chains: block, roller and what are known as silent chains. Block and roller chains are most often used for connecting up two or more shafts of a machine to give a positive ratio between them. Block chains are seldom used for power transmission of over a few horsepower, but are fre-

quently used on small machines, like bicycles and other light devices. Well-designed roller chains are used commonly up to about 25 to 30 hp. and in some cases much higher.

Block chains consist of a solid link joined by a pin and side plates. The pitch of a block chain is the distance from the center of one tooth opening to the center of the next, or, as it is most often measured, from the center of one pin to the corresponding pin in the next link.

Roller chains consist of links or plates fastened together by pins fitted through rollers, although some cheap grades are fastened by pins only and are not adapted to high speed or heavy service. In most roller chains the links are of equal length and so the pitch, the distance from pin to pin, is approximately one-half of that of block chains of corresponding size of links which have twice the pitch. In this way a sprocket for a roller chain has twice as many teeth as a sprocket for a block chain of twice the pitch. The corresponding pitch of the three types of chain are made clear by the sketches reproduced on page 337. Roller chain operates much more smoothly than block chain as it fits over a larger number of teeth and may be used at a higher speed.

Roller chains are sometimes run at speeds of 2,000 ft. per min., but speeds of 1,000 ft. per min. or less are much more satisfactory. Block chains are adapted to lower speeds, 700 to 800 ft. per min. or less. If the speed and load are not fixed qualities it is advisable to keep the speed high and the chain pull low,



A motor connected by roller chain to an air compressor, for direct drive.

Air compressor drives are hard on chains. Here, however, the impulse shocks are taken care of partially by the momentum of the flywheel. The construction of a roller chain can easily be seen. It is made up of a series of inside and outside links fastened together by pins on which loose rollers are fitted.

and it should be remembered that high speeds are more destructive to chains of large pitch than to those of small pitch as will be explained elsewhere in this article. Therefore, the use of chains having a short pitch and a proportionate increase in width is recommended. A disadvantage of both of these types of chain lies in the limitations on increasing the width so as to add to capacity.

Construction and Some of the Applications of Silent Chains

Silent chains are made up of special types of pins, connecting links so designed as to provide on the chain a tooth which fits into the tooth on the sprocket. They are in reality flexible racks; when straight, as in between sprockets, a chain acts as a rack and when passing over a sprocket acts as a reflex gear. It is similar in effect to two gears with about half their teeth in mesh except that the load is divided among them instead of being all on one tooth, as is the case with gears. The construction and operation of silent chains is shown in some of the accompanying illustrations. The pitch of silent chains is the distance between the centers of pins in a chain. Sprockets do not have pitch dimensions, as do gears, but are designed to take a certain pitch of chain.

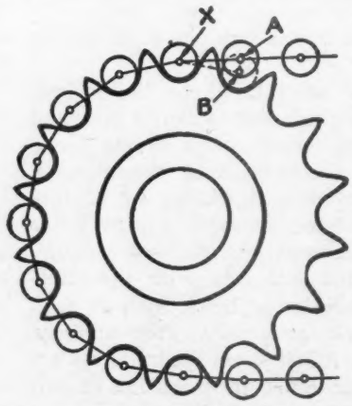
Silent chains are made in varying capacities from fractional horsepower to one large installation of 5,000 hp. They may be constructed in any width but for ease in handling are seldom made wider than eight times the pitch. In case a wider chain is necessary, two chains are used or else a chain of a larger pitch.

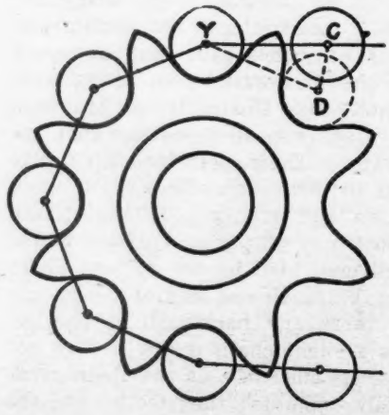
Originally, chain drives were installed where gears could not be used, except in trains with heavy friction loss, where belts gave trouble, or where it was desired to give a positive ratio between machine elements. At present, in addition to these, many other installations are being made, particularly on machines in continuous operation, where each revolution means a definite amount of production, as with some textile machines, automatic punch or stamping presses, screw machines and numerous other machine tools.

With chain drives, every revolution of the driver means a definite number of revolutions of the driven wheel (according to the speed reduction ratio) and this ratio is always maintained until the chain or sprockets are worn out. Belts, when operated under the best conditions, give a low slippage loss, but if they are neglected and allowed to loosen up the slip is more. This loss is not noticed ordinarily as it is a gradual increment. In actual instances textile mills have increased output as high as 10 per cent and the output of machine tools has been increased

This is the explanation of why pitch and revolutions per minute are the limiting factors in chain drives.

As stated in the text, the pitch and the revolutions per minute of the sprocket are of more importance in determining chain-drive limitations than chain speed in feet per minute. As shown in these drawings one sprocket has ten teeth and the other twenty, and the pitch of the chain on the wheel with ten sprockets is twice that of the other. If the revolutions per minute are the same in both cases, the point **A** will reach point **B** in the same length of time as point **C** will reach its point of rest, **D**. However, the distance **C** to **D** is twice that of **A** to **C** and so the larger chain will strike its sprocket at twice the velocity of the one with a smaller pitch. As the force of the blow increases with the square of the velocity, the large chain "hammers" the sprockets four times as hard as the small chain, although both are traveling at the same speed in ft. per min. If the diameters of the sprockets are increased, without increasing the revolutions per minute, the force of the blows does not increase correspondingly, although the speed in feet per minute and the horsepower capacity have both been thereby increased.



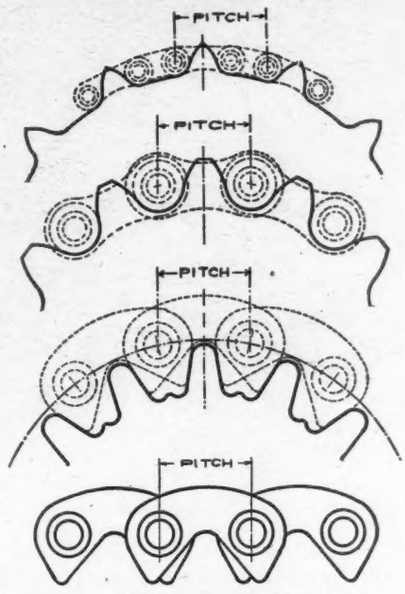


up to 18 per cent, merely by a change in drive.

Factors Governing the Installation of Chain Drives

In installing chain drives the governing factors are the revolutions per minute, the horsepower, and the minimum diameter necessary on the sprocket wheel, which limits the number of teeth. Chains are made of steel, tempered and slightly annealed to give toughness. However, the chains strike a series of hammer blows against the sprockets at each revolution and this will eventually affect the steel, if the blow is too hard. The force of this blow increases with the revolutions per minute (instead of the speed) and with increased pitch. For this reason chains of small pitch should be used with high speed as they do not hit as violent a blow. Why this is so is explained in the caption under the drawing reproduced on page 336. It is often possible to increase the diameter of the sprockets and so decrease the necessary revolutions per minute to get the same power transmitted as the power is a function of the speed of the chain. On properly designed chain-drive installations these hammer blows do not affect the life or operating conditions as they may if the drive is improperly designed.

What relationship should exist between chain pitch, revolutions per minute and horsepower can best be obtained from the manufacturer of the particular chain to be installed as they vary somewhat with each different type of chain drive manufactured. In general, however, it is not advisable to use a sprocket with less than 13 teeth and preferably with at least 15 or 17, or more if possible, depending on the pitch. Even with the smallest pitch of silent chains, 35 to 45 teeth in the sprocket



How the pitch is measured on block, roller and silent chain drives.

These three chains are all drawn to scale so that they are the same pitch. The block chain is at the top, roller next, and silent chains in the two lower illustrations. It may be seen from this why block chain sprockets have only half the teeth and also why the chains are much smaller for the same pitch. It should be remembered that chain sprockets have no pitch line or measurement as is used in connection with gears. On the silent chains what might be called the pitch circle is outside the end of the teeth. How to order sprockets will be told in the next article.

are desirable. Also, it is desirable to have an even number of links in the chain and an odd number of teeth in the sprocket as such a condition gives more uniform wear because it prevents the same teeth and links from making regular, repeated contacts. If the center distance is absolutely fixed it is sometimes necessary to use a special connecting link which is called a "hunting link" and is so designed that three links take the place of four and makes the number of links in the chain odd. An odd number of links or pitches in a roller chain are connected up by what is known as an "offset" link.

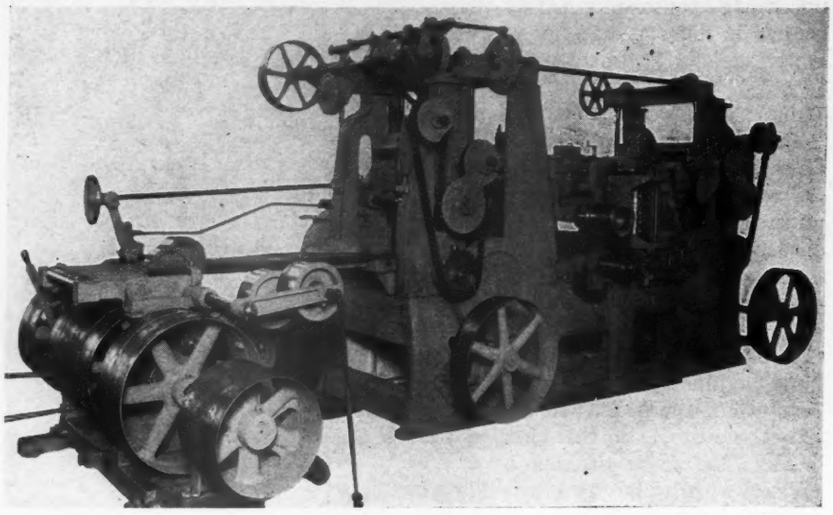
The width of sprockets should be at least 1.2 times the pitch. Ordinarily, it is not desirable to drive silent chains at over 1,200 to 1,600 ft. per min. Many installations are working satisfactorily at much greater speed, but at a sacrifice of quiet operation, short life and high maintenance in some cases. Installations above this recommended speed or having any other unusual features, should be referred to the manufacturer's engineering department for approval or special modifications for that particular installation. It is always advisable to avoid vertical drives, especially with the small sprockets below as a loose chain or any wear or elongation of the chain will cause it to ride high and wear off the tops of the sprocket teeth in the same way that they do when the links are elongated, as shown in the sketch reproduced on page 338. If too much slack is allowed the chain will jump the teeth.

The effect is not so bad if the large sprocket is used below but a horizontal drive is most satisfactory. A slack of about ¼ in. to ½ in. drop per foot of span is recommended. It is almost essential on vertical drives to provide some means of take-up for adjusting wear and stretch, and it is usually desirable on horizontal drives. However, chain drives, except on vertical drives, operate better if one side is slack. The best method of taking up slack is by an adjustable base or mounting plate, although idlers may be used. However, in case an idler is used it should be as large as possible and never below the minimum number of teeth recommended for that pitch of chain. The idler should have teeth the same as any other sprocket and be used on the inside of the slack side of the chain. In cases of necessity, such as getting around obstructing shafts, rawhide or fiber idlers without teeth are sometimes used on the back of chains but this is to be avoided whenever possible as it gives a reflex bending to the chain and adds that much more friction to the drive.

A chain needs a side clearance

Four chain drives, each operated by an individual motor, are installed here on oil presses at a linseed oil plant.

This is an excellent illustration of a compact arrangement. Other types of drives would require that the motor be several times as far from the driven shaft. This would increase the distance between the presses.



Here roller chains are used to connect feeds and cutting tools.
Where it is desired to have a positive ratio between two or more working elements on a machine, gears or chains must be used to connect them up. This "sizer" will take a timber 16 in. thick by 20 in. wide.

equal to the pitch to prevent rubbing and wearing on the sides. A silent chain will stay on the sprockets without any guide if the sprockets are parallel and properly aligned. However, the manufacturer of each type of chain provides some method of holding it on the sprocket as a precaution in case a sprocket should slip. For example, block and roller chains fit around the teeth of the sprocket and so can be used on equipment where the alignment varies, as in automobile drives, due to the swaying of the body and rough roads.

One method of holding a silent chain in position is by a flange or shroud. These are made from steel plates fastened to the side of the sprocket or, in some cases, of wire crimped to fit into the teeth and fastened around the edge of the wheel. For these, the wheel must be wide enough to take the crimped wire for the flange. This is easy to apply and does not interfere with the cutting of the teeth. Other methods used are to provide solid links in the chain which fit into a groove in the sprockets or in some cases over the ends of the teeth on the outside of the sprocket. When a chain shows signs of wearing either the flange, the groove in the sprocket or the solid links fitting into the chain, it indicates that the sprockets are out of alignment.

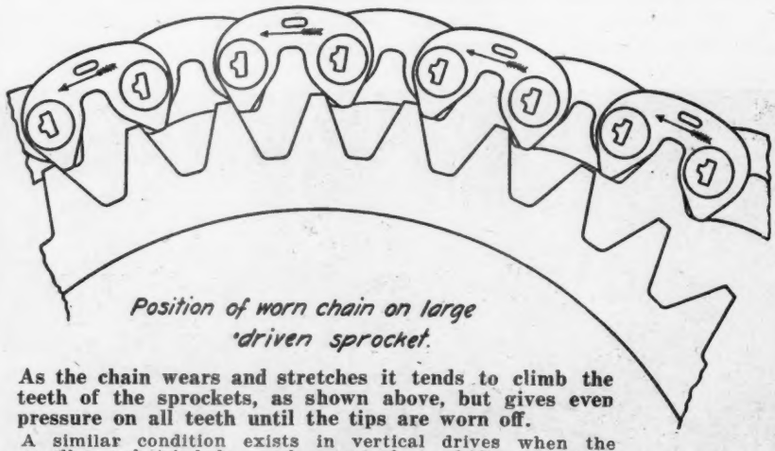
How the Wear Affects Chains and Sprocket Teeth

As silent chains wear the pitch of the link lengthens from two causes: the very slight stretch of the link and the wearing of the connecting pins or the holes in which they fit. This causes silent chains to ride high on the teeth of the sprocket, as shown in the sketch at the right, which is exaggerated somewhat, and wear away the ends of the teeth. This elongation must not exceed ⅜ in. per ft. The chains, however, still exert an even pressure on all the teeth until the tips of the teeth are worn away so that the chain slips. This can be partially corrected by repinning the chain, that is, by using new pins and bushings slightly larger to compensate for the wear. This is best done by the manufacturer in his factory but may be done at the industrial plant over the Sunday shut-down if samples of worn links are first sent to the factory to get the proper size of pin or bushing. Two sample links should be sent which are taken, one from each side and about midway between the center and the edges of the silent chain and in the same row crosswise.

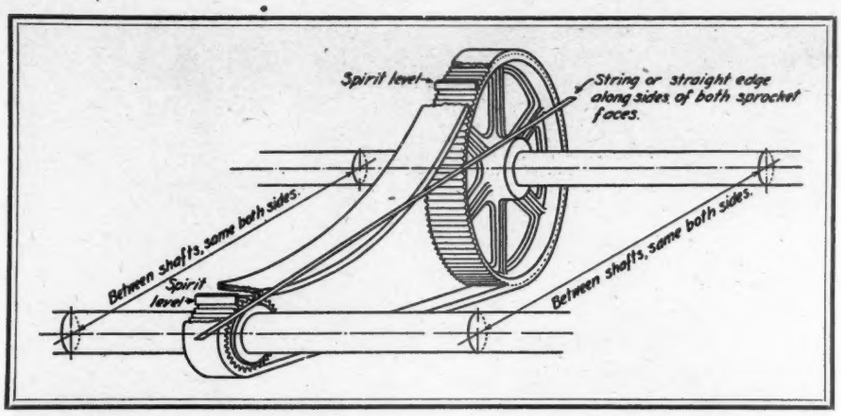
Ordinarily, a sprocket may be expected to outlast three new chains or one chain twice repinned. Chains and sprockets in excessively dusty locations, particularly around cement and ashes, wear more than ordinary. In the average industrial plant if a chain is taken care of, as will be explained later in this article, this wear due to foreign matter is of little consequence.

Block and roller chains stretch and lengthen the pitch in the same way as do silent chains. However, instead of exerting an even pressure on all the teeth, all the load is concentrated on one tooth with the others not touching the chain, or, if the wear is excessive the chain also makes contact with the back of a tooth. The sprocket teeth also wear near the base into a hook shape. This wear is increased if the tooth is of improper shape. With properly designed teeth the chain tends to ride higher as the pitch increases and so does not wear the tooth into a hook shape. Considerable effort has been made towards standardization of some sizes and shapes of block and roller chains and the sprockets and teeth so that the user may be more sure of getting the same size even if he should order from different manufacturers. Standard roller chains are made in the following pitches: ⅜-in., ½-in., ⅝-in., ¾-in., 1-in., 1¼-in., 1½-in., 1¾-in., 2-in., 2½-in. and 3-in.

The number of teeth in roller chain sprockets should be as large as is consistent with the conditions. A larger number of teeth reduces



As the chain wears and stretches it tends to climb the teeth of the sprockets, as shown above, but gives even pressure on all teeth until the tips are worn off.
A similar condition exists in vertical drives when the small sprocket is below, unless some form of idler or adjustment is used to maintain contact.


Spirit level
String or straight edge along sides of both sprocket faces.
Between shafts, same both sides.
Spirit level
Between shafts, same both sides.

One of the most important features of installing chain drives is to get the sprockets aligned and to have the lineshafts parallel.

A spirit level on the face of the teeth shows whether the sprockets and lineshaft are level. It is also necessary to check the distance between the shafts on both sides, as shown, to see if the shafts are parallel. The alignment may be checked with a string or a straight-edge stretched across the face of the sprockets as shown, and should be checked up frequently, as the sprockets may slip. Slip or misalignment may be seen by observing the guide links in the chain and the groove in the sprocket to see if they are worn equally on both sides, or by noticing the wear on the flanges and outside links of the chain. After trying the straight-edge in one position it is well to turn the larger sprocket a third of a revolution and again test, both as a check on the first test and also to determine whether the shafts are parallel. This method may be used when it is not practicable or is difficult to measure the distance between the shafts.

the noise, the wear of the chain on the sprockets, and the loss of energy from friction. The best results are obtained from sprockets having sixteen teeth or more. Eight- or nine-tooth sprockets will almost invariably ruin a roller chain, and those having ten or eleven teeth are only adapted for medium and slow speeds with other conditions favorable. The speed of the chain is not as important as the revolutions per minute and size of sprockets. It is better to use large sprockets and increase the speed of the chain than to use small sprockets for the same power transmission in order to secure a lower-speed chain.

With larger sprockets the angular motion or friction between pins and bushings is reduced and the chain pull is less. The ratio between the driven and the driving sprocket should not be over 1 to 8 for block chains of the bicycle type nor over 1 to 5 for roller chains of ⅝-in. pitch or over. A center distance of thirty-five to forty times the pitch of a roller or block chain gives the best results. More center distance than this creates an excessive chain sag resulting in a centrifugal whip, which in time ruins a chain.

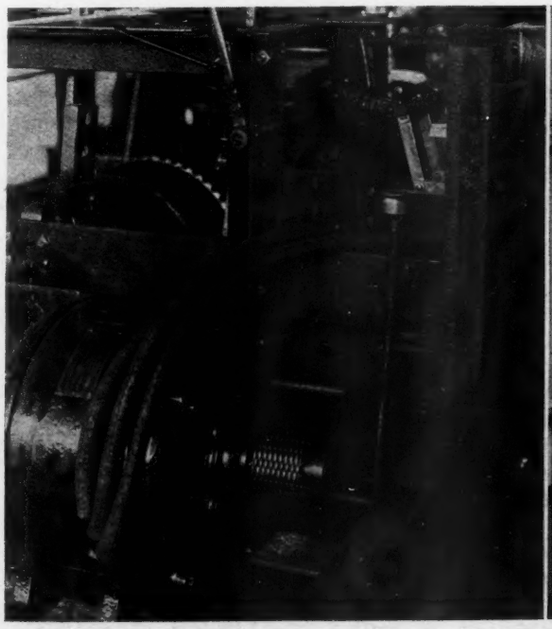
Some Methods of Lubricating the Different Chain Drives

The manufacturers of block and roller chains and of most silent chain drives recommend that the chain run in an oil bath if under heavy load or in continuous operation. In one case, however, it is claimed that this is not necessary if the chain is frequently cleaned and regreased. The wear on chains comes on the pins, between the chain and the teeth; and in the side wear due to the rubbing of the sides of the links against each other in the constant bending and straightening out as the chain passes over the sprocket. One big advantage of the oil bath is that it lubricates in all these points. Grease is frequently used on block or roller chain and on some silent chains. In dusty locations chains should at least be encased, even if not running in oil. For the safety of operation and workmen it is well always to have chain drive enclosed.

Probably the easiest method of cleaning any form of chain is to remove it at least once a month, or more often in dusty locations, and souse it in kerosene. If more convenient, it may be cleaned by steam. In all cases it should be lubricated before using. Oil in the chain case should be (*Continued on page 372*)

Silent chain drive on a baler.

Here the motor is connected to a worm shaft which gives additional speed reduction.



This 750-hp. motor drives a lineshaft in a rubber mill.

The motor operates at 350 r.p.m. through a 21-tooth pinion sprocket which drives an 81-tooth split wheel at 82 r.p.m. The centers are 108½ in. with a chain of 2½-in. pitch.

IN THIS ARTICLE Mr. Dudley shows that chord factor deals with the pitch or throw of the coil and whether it does or does not surround the whole of the mechanical pole and that distribution factor deals with the phase of the winding and the groups or bands per pair of poles into which each phase winding is distributed or arranged. He also shows that distribution factor is a measure of how effectively the turns in the winding are used. Mr. Dudley is the author of Connecting Induction Motors and is a well-known authority on this subject.

This is a Simple Explanation of

Distribution and Chord Factors

And the Uses That Are Made of Them in Winding Stators of Induction Motors

By A. M. DUDLEY

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

IN A GENERATOR or motor the magnetic field which is set up is proportional to the *ampere turns* in the winding. That is to say, the magnetic field is influenced directly by the number of turns of wire surrounding the magnetic circuit and by the number of amperes of electrical current flowing in these turns. In the case of a direct-current machine where the field coils have the familiar form shown in Fig. 1, this is very easily calculated because the turns are all concentrated in a group and completely surround the mechanical pole structure in which they are setting up a magnetic field. Such a coil or field winding is called *concentrated.*

In the case of a *distributed* winding shown in Fig. 2, which is usually used on induction motors and other alternating-current motors, the case is not so simple. The effective ampere turns or magneto-motive force is not obtained directly by multiplying the number of turns by the amperes flowing, but must be modified by two factors called *chord factor* and *distribution factor.* The first of these deals with the *pitch* or *throw* of the coil, which means whether it does or does not surround the whole of the mechanical pole, and the second has to do with the *phase* of the winding—that is, whether it is single phase, two phase, or three phase —and in how many groups or bands per pair of poles each phase winding is distributed or arranged.

What is meant by *current bands* is groups of adjacent conductors in which the current is of the same phase and flowing in the same direction. This can be understood from consideration of Fig. 3, diagrams *A* to *F* inclusive, which represent a portion of a typical induction motor winding and the current conditions which exist in such a winding when variously connected for two phase or three phase, with standard connection or consequent-pole connection.

Diagram *A* shows twelve slots of the stator core of an induction motor and the twelve coils that lie therein. These coils have a throw of slots 1 and 7, which in this case is assumed to be full pitch. The portion of the winding shown covers 360 electrical degrees; that is, from the center of one north pole to the center of the next north pole. The coils as shown are unconnected, the terminal wires for the beginning and ending of each coil being brought out and marked *1b, 1e, 2b, 2e,* and so on.

In diagram *B* are represented the current conditions that would exist in the winding of diagram *A* if the coils were connected to form two

pole-phase-groups of a single-phase winding. The top line marked Way Coils Are Connected is a schematic diagram showing the coil-to-coil connections and the group connections for such a connection. The small coil marked *1* represents the coil lying in slots No. 1 and No. 7 of diagram *A*, having the wire marked *1b* in diagram *A* brought out for a lead, *A*, and having the wire marked *1e* connected to *2b* on coil No. 2, and so on. In this manner coils 1 to 6 inclusive are connected in series to form a pole-phase-group, and coils 7 to 12 inclusive are connected in series to form a second pole-phase-group. These two groups are then properly connected to form an adjacent north and south pole in the winding. The next horizontal picture in diagram *B* marked Cross Section of Coils and Core shows the direction of the current in each slot and is shown as if a cross section of all coils were taken along the line *XY* shown in diagram *A*. Conductors in which current is assumed to be flowing away from the observer are marked *X* and conductors in which the current is assumed as flowing toward the observer are marked with a circle and dot in the center. The slots are marked 1 to 12 inclusive. A consideration of the currents in all twelve coils shows that they come in groups or bands of twelve conductors in one direction and then twelve in the opposite direction. Therefore, the current bands are as shown by the wide black lines at the bottom of diagram *B*, and also as shown there are two current bands per pair of poles. In Fig. 6, as discussed below, is shown the geometrical derivation for the distribution factor of such a winding.

Diagram *C* of Fig. 3 shows the corresponding conditions which would exist if the coils of diagram *A* were connected for two-phase, two-pole as schematically indicated at the top of diagram *C*. An examination of the *current bands* at the bottom of diagram *C* shows that there are four current bands per pair of poles. For convenience, in the current bands *A* phase current is shown by circles and *B* phase by squares. Fig. 4 shows how the distribution factor for such a connection is derived.

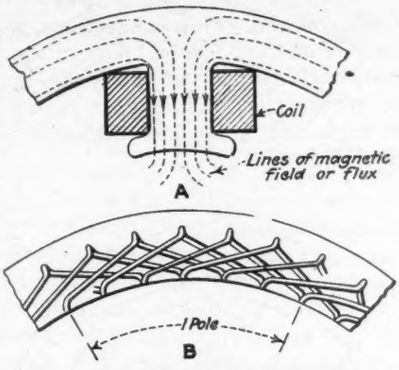


Fig. 1 — Direct-current machine showing concentrated field winding. Fig. 2 — Alternating-current machine showing distributed field winding.

Again, diagram *D* of Fig. 3 assumes that the coils of diagram *A* have been connected for two-phase, two-pole, but with a *consequent pole* arrangement; that is to say, with all pole-phase-groups, for example, connected to produce north poles and letting the south poles result from the magnetic flux finding its way back in between the north poles as best it can. There are only two current bands per pair of poles as shown at the bottom of diagram *D*. In this case current bands for the top coils in the slot alone are shown. The distribution factor of such a winding may be derived from Fig. 4, as explained below, and is the same as for the single-phase winding of diagram *B*. Such a connection might be found on the slow-speed connection of a two-speed winding.

Similarly, diagram *E* of Fig 3 shows the conditions if the coils of

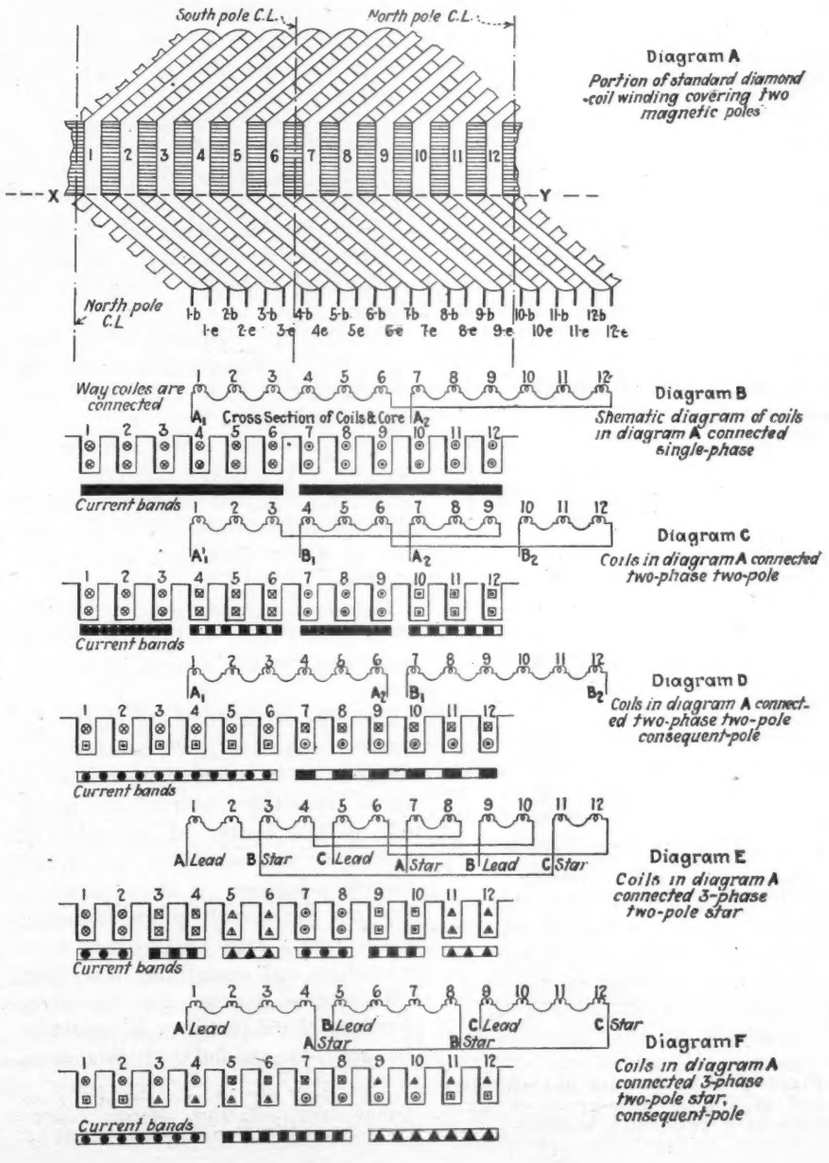

South pole C.L.
North pole C.L.
Diagram A
Portion of standard diamond coil winding covering two magnetic poles
X
Y
North pole C.L.
Way coils are connected
Cross Section of Coils & Core
Diagram B
Shematic diagram of coils in diagram A connected single-phase
Current bands
Diagram C
Coils in diagram A connected two-phase two-pole
Diagram D
Coils in diagram A connected two-phase two-pole consequent-pole
A Lead B Star C Lead A Star B Lead C Star
Diagram E
Coils in diagram A connected 3-phase two-pole star
A Lead B Lead C Lead C Star
A Star B Star
Diagram F
Coils in diagram A connected 3-phase two-pole star, consequent-pole

Fig. 3—Portions of typical induction motor windings and current conditions when variously connected.
In these diagrams marked A to F are shown the current conditions which exist when an induction motor winding is variously connected for two-phase or three-phase with standard connection or consequent pole connection.

diagram *A* are connected for a standard three-phase, two-pole, star connection as shown by the schematic diagram at the top. For convenience, in the *current band* diagram at the bottom of diagram *E* the *A* phase current is represented by circles, the *B* phase by squares, and the *C* phase by triangles. It will be seen that there are six current bands per pair of poles, and hence such a connection really has as good a distribution factor as a six-phase winding. The manner of deriving the distribution factor for this winding is explained in connection with Fig. 5 below.

Finally, diagram *F* of Fig. 3 shows the conditions where the coils of diagram *A* are connected for three-phase, two-pole-star, but with a *consequent-pole* arrangement. It will be seen that there are three current bands per pair of poles. The distribution factor for this connection can be obtained from Fig. 5, as explained below. It will be noted that this connection, which is a real three-phase connection, has a distribution factor of only 0.827, whereas the usual three-phase arrangement of diagram *E* which, in turn, is really six-phase, has a distribution factor of 0.955. This is the explanation of why six-phase rotary converters are greatly to be preferred over three-phase, although requiring the increased complication of six sets of brushes and six collector rings as against two sets of brushes and three collector rings on a straight three-phase rotary.

With this preliminary physical conception of how the distribution factor is affected by the arrangement of the coil and group connections, a ready transition can be made to the geometric method of determining the value of the distribution factor as explained below in connection with Figs. 4, 5 and 6.

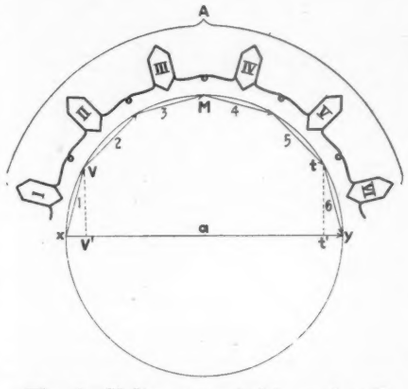


Fig. 6—Volts generated in each coil and in a pole-phase-group of six coils in a single-phase winding.

In calculating the windings for an induction motor, the number of turns required in the coils is found from this expression:

**Conductors per phase* = *(45,000,000 × volts per phase) ÷ (Cycles × magnetic flux per pole × $K_1 \times K_2$).* In this formula:

Conductors per phase = (Number of wires per slot which are in series × number of slots) ÷ number of phases.

Cycles = the frequency of the supply circuit as expressed in cycles per second, that is, 60 or 25, or whatever the circuit may be.

Volts per phase = line volts in the case of a two-phase winding or a delta-connected three-phase winding and line volts divided by 1.73 in the case of a star-connected three-phase winding.

Magnetic flux per pole = number of magnetic lines of force set up in each pole by the magnetizing current.

K_2 is the so-called *chord factor* depending upon the pitch or throw of the coil. *Full pitch* would mean a throw from the center of one north pole to the center of an adjacent south pole and would be called 180 electrical degrees. A *chorded winding* or *fractional pitch* winding would have a span or throw of each individual coil something less than 180 electrical degrees, and the corresponding *chord factor* or K_2 would be the *sine of one-half of this span angle.* In the case of full pitch or 180 deg., the *sine of one half of 180 deg.* or *sine of 90 deg.* = 1, and hence the turns of a winding are most effective in inducing or generating voltage when the throw of the coil is full pitch. In actual practice this is usually not done because chording one or two slots does not seriously affect the voltage generated and results in some saving of wire due to the physically shortened length of the average turn of wire in the coil.

K_1 is a different kind of factor and depends upon the phase of the winding: that is, whether it is a two-phase or three-phase or single-phase winding. It is usually called the *distribution factor.* For most of the present day distributed windings used in induction motors it can be placed equal to 0.905 for two-phase windings and 0.955 for three-phase windings and practical calculations based on these values will be accurate within close limits. In the case of single-phase windings, as explained below the *distribution factor* becomes more involved and must be worked out for each individual case.

In Fig. 1, is suggested a cross section of one pole and a part of the field yoke of a direct-current machine. In Fig. 2 is indicated a part of one end of the stator winding of an induction motor without any cross connections or leads. Consider first Fig. 1. It is readily seen that each turn of wire in the field coil surrounds all the magnetic lines of force which thread through the coil and make up one magnetic pole of the field circuit. On the other hand, in Fig. 2, it is seen that not only does

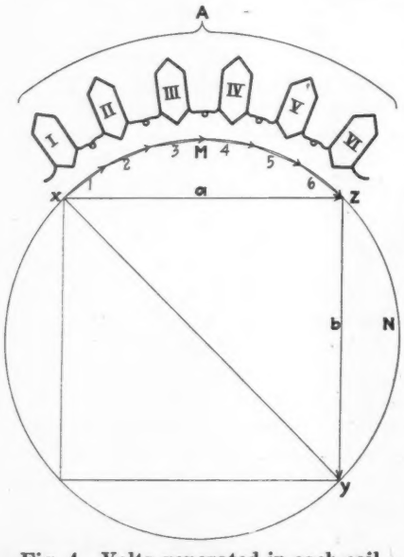


Fig. 4—Volts generated in each coil and in a pole-phase-group of six coils in a two-phase winding.

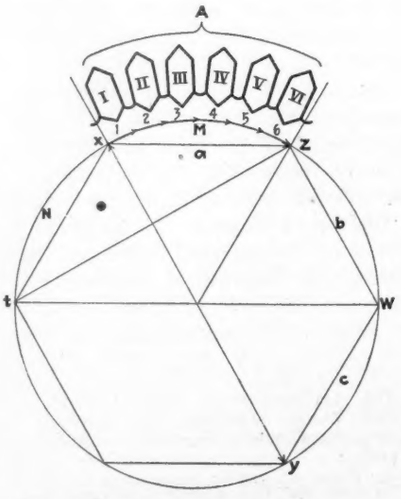


Fig. 5—Volts generated in each coil and in a pole-phase-group of six coils in a three-phase winding.

*See page 190 of the writer's book "Connecting Induction Motors," published by McGraw-Hill Book Company.

each coil not surround all the magnetic field flux of one pole, but that there is, in addition, the complication that the magnetic field which acts as if it were set up by direct current, relies on the combination of two or three phases of alternating currents in the windings to produce this effect of a rotating direct current for magnetization.

It is the difference in the action of two-phase windings from three-phase windings that gives rise to the difference between the values of 0.905 and 0.955 cited above, and the physical reason for this difference can best be seen from geometric figures.

In Figure 4 is represented a half square erected in a semi-circle, the diameter of the circle becoming one diagonal of this inscribed square. This figure represents diagrammatically the voltages set up or induced in each individual coil in a two-phase winding, which would be the small chords subtending the small arcs *1, 2, 3, 4, 5, 6.* The coils themselves are physically pictured as *I, II, III, IV, V, VI;* also the voltage in one pole-phase-group is represented by the sides of the square *a* or *b*, where *a* would be the *A* phase and *b* the *B* phase. It also represents in the diameter of the circle *XY* the voltage induced by one rotating magnetic or *direct current* pole, which is the result of the combined action or interaction of the two-phase windings *a* and *b*.

The physical interpretation of the diagram in Fig. 4 is that if the small coils *1, 2, 3,* and so on, represent six individual coils in series forming one pole-phase-group of a two-phase winding, each coil will generate or have induced in it a voltage represented by the short chord or straight line subtending the arc representing this coil. The six coils in series would generate a total voltage equal to the sum of the six chords or practically equal to the quadrant of the circle from *X* to *Z*. This quadrant represents in its length the voltage that would be generated or induced in the pole-phase-group if all six of the coils were bunched into one coil as in the case of the direct-current machine shown in Fig. 1. However, these six coils are not bunched but are spread over an arc in the bore of the motor representing one *pole pitch*. For this reason there is a phase difference in time represented by the small angle between the chords *1* and *2*, which means that because the main magnetic field in the motor is rotating, it does not generate voltage in coil *1*, for example, at exactly the same instant that it does in coil *2*, but a fraction of a second sooner or later. Since this is true, we cannot add together end to end in one straight line the six small voltages generated by the six coils, but must add them geometrically as shown in Fig. 4, so that instead of having a voltage across the six in series, or the pole-phase-group, practically equivalent to the arc *XMZ*, the combined voltage is really the chord of this arc or the straight line *XZ*. Theoretically, the number of coils in the pole-phase-group would have to be infinite before the arithmetical sum of their voltages would be equal to the quadrant of the circle, but practically in most commercial motors this assumption can be made without serious error.

Now since the arc *XMZ* represents in its length what the combined voltage of the six coils would be if bunched or concentrated into one coil, and since the chord or straight line *XZ* represents by its length what the real voltage across the six is (since they are not quite in phase), the actual effective number of turns or what is called the *distribution factor* can be represented by the expression:

Distribution Factor = (The length of the chord XZ) ÷ [The length of small chords (1+2+3+4+5+6)].

And, since in practically all commercial windings there is a considerable number of coils in each pole-phase-group, the sum of the chords *(1+2+3+4+5+6)* can be set equal to the arc *XMZ*, as stated above, and the expression for distribution factor becomes:

Distribution Factor = (The length of the chord XZ) ÷ (The length of the arc XMZ).

Since these quantities make up the quadrant of a circle, the chord *XZ* = the radius of the circle ÷ 0.707 and the arc *XMZ* = 3.14 × the radius of the circle ÷ 2.

The expression above then becomes:

Distribution Factor = (Radius × 2) ÷ (0.707 × 3.14 × Radius) or 2 ÷ (0.707 × 3.14) = .90.

When this value is worked out for a number of practical cases involving different numbers of coils per pole-phase-group, it is found that the value 0.905 given in the general paragraph above is a satisfactory one to be used in the calculations for ordinary commercial machines.

Fig. 4 can be used, also, to derive the distribution factor for a consequent-pole winding such as that illustrated in diagram *D* of Fig 3. In this case the diameter *XY* represents the voltage induced in the winding for one pair of poles, that is to say the winding A_1-A_2 for example. This voltage may be considered as made up of the two voltages or chords *XZ* and *ZY*. In return, the voltage *XZ* may be considered the voltage set up by the physical winding making a north pole, and the voltage or chord *ZY*, representing the *consequent* pole or resulting south pole which has no winding but which is obliged to be present in order for the magnetic flux sent out by the winding to get back into the core. In other words, the direction of the current in the windings is such as to cause only one polarity, but since one polarity cannot exist without the other, the other polarity comes *in consequence* and hence is called a *consequent* pole. Referring again to Fig. 4, if the sum of all the voltages in all the individual coils is equivalent to the arc *XMZNY* and the resulting voltage at the terminals A_1-A_2 of the winding is represented by the diameter *XY*, the distribution factor is the expression:

XY ÷ (arc XMZNY) = (2 × radius) ÷ (3.1416 × radius) = 2 ÷ 3.1416 = 0.636.

This is the same as the single-phase distribution factor in Fig. 6. Another conception of this factor of 0.636 would be to say that it is the product of 0.905 and 0.707, the first being the relation of the chord *XZ* to the arc *XMZ*, and the second being the relation of the diameter *XY* to the sum of the chord *XZ*, plus the chord *ZY*. In other words, the factor 0.905 is because the winding is two-phase, and the factor 0.707 is because it is connected for consequent poles, and the product of 0.905 × 0.707 = 0.636, which makes it no better than the single-phase winding shown in Fig. 6.

Considering Fig. 5, there is illustrated a similar condition for a three-phase motor. In this case the construction is that of a hexagon inscribed in a circle. Again, the coils are physically pictured as *I, II, III, IV, V, VI* and the voltages induced in each of these coils, or the magneto-motive force set up by each, as the small chords *1, 2, 3, 4, 5, 6.* If these coils were all concentrated into one large coil, their effect would

equal the sum of the small arcs *1, 2, 3, 4, 5, 6*. Since this is not the case and they are distributed as shown, the effect of the pole-phase-group is the chord *XZ* or *a*. Then, similarly to the two-phase case, the expression for the distribution becomes: (The length of the chord *XZ*) ÷ (The length of the arc *XMZ*). Since the chord *a* in this case is one side of an inscribed hexagon, and since the side of a hexagon is equal to the radius of the circle in which it is inscribed, this expression becomes: (Radius of a circle) ÷ (One sixth of the circumference) = (6 radius) ÷ (2 × 3.14 × radius) = 3 ÷ 3.14 = 0.955 which it is proper to use in all practical calculations for ordinary commercial machines.

From Fig. 5 may also be derived the distribution factor for a three-phase, consequent-pole winding such as that illustrated in diagram *F* of Fig. 3. In this case the chord *tz* represents the voltage induced at the terminals of one phase of the winding, as for example between the *A* lead and the *A* star. As in the case of the similar two-phase, consequent-pole winding described under Fig. 4 and diagram *D* of Fig. 3 this voltage *tz* is made up of the pieces *tx* and *xz* combined. Of these two pieces we may consider *xz* as actually caused by the ampere turns in the winding and *tx* as resulting from the consequent pole similar to the two-phase case above. Hence the distribution factor for this winding is the length of the chord *tz* divided by the length of the arc *tnxmz* or approximately 0.827. This factor can be considered as made up of 0.955 × 0.866. The first of these is due to its being a three-phase winding, as already explained above, and is the relation of the chord *xz* to the arc *tmz* and the second factor or 0.866 being due to the consequent-pole connection. This factor 0.866 is the relation of the chord *tz* to the sum of the chords *tx* + *xz*.

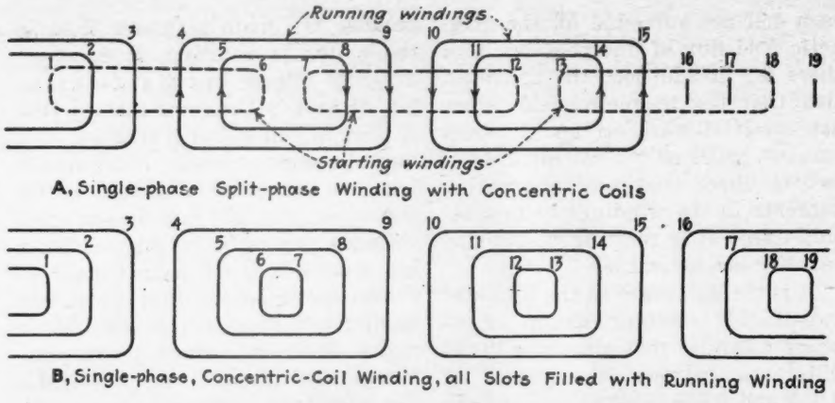

Running windings
Starting windings
A, Single-phase Split-phase Winding with Concentric Coils
B, Single-phase, Concentric-Coil Winding, all Slots Filled with Running Winding

Fig. 7 — Single-phase, split-phase winding with concentric coils.
Fig. 8 — Single-phase concentric coil winding having all slots filled with the running winding.

The case of a single-phase winding, if completely distributed as shown for a two- or three-phase winding, is shown in Fig. 6. Here the illustration shows neither a square, nor a hexagon, nor a triangle inscribed in a circle, but simply the diameter of the circle itself, *xy*, is used to represent the electrical or magnetic effect of the pole-phase-group made up of the coils *I, II, III, IV, V, VI*. As in the previous cases, if the six coils were concentrated into one field coil, their total effect would be measured by the sum of the chords *1+2+3+4+5+6*. Since they are distributed and hence each one has a little different phase from the others, the combined effect of the pole-phase-group is *xy* and the expression for the distribution factor becomes:

(Diameter of a circle) ÷ (One-half the circumference) = *D* ÷ (3.14 × radius) = 2 ÷ 3.14 = 0.636.

This factor shows that there is a very inefficient use of copper because it means that something less than two-thirds of the actual number of turns in the winding is actually effective in producing the magnetic field or in inducing voltage from that field. From the figure it will be seen that the two end voltages of the group No. *I* and No. *VI* are so far out of phase as to be of little value, and that if they were left out of the winding *(Continued on page 355)*

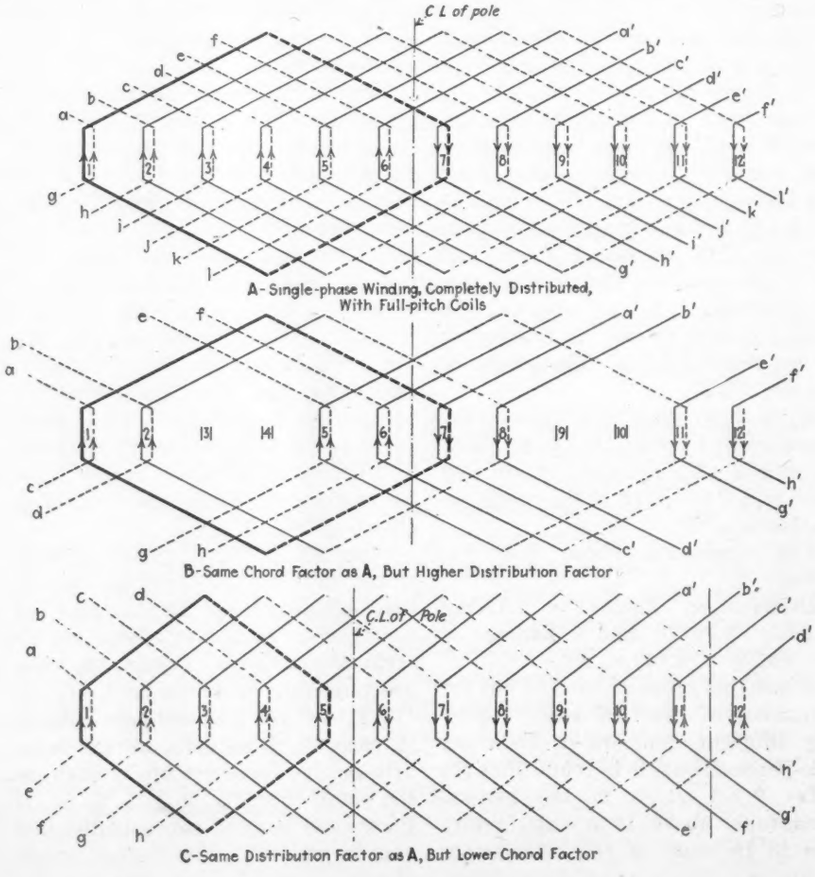
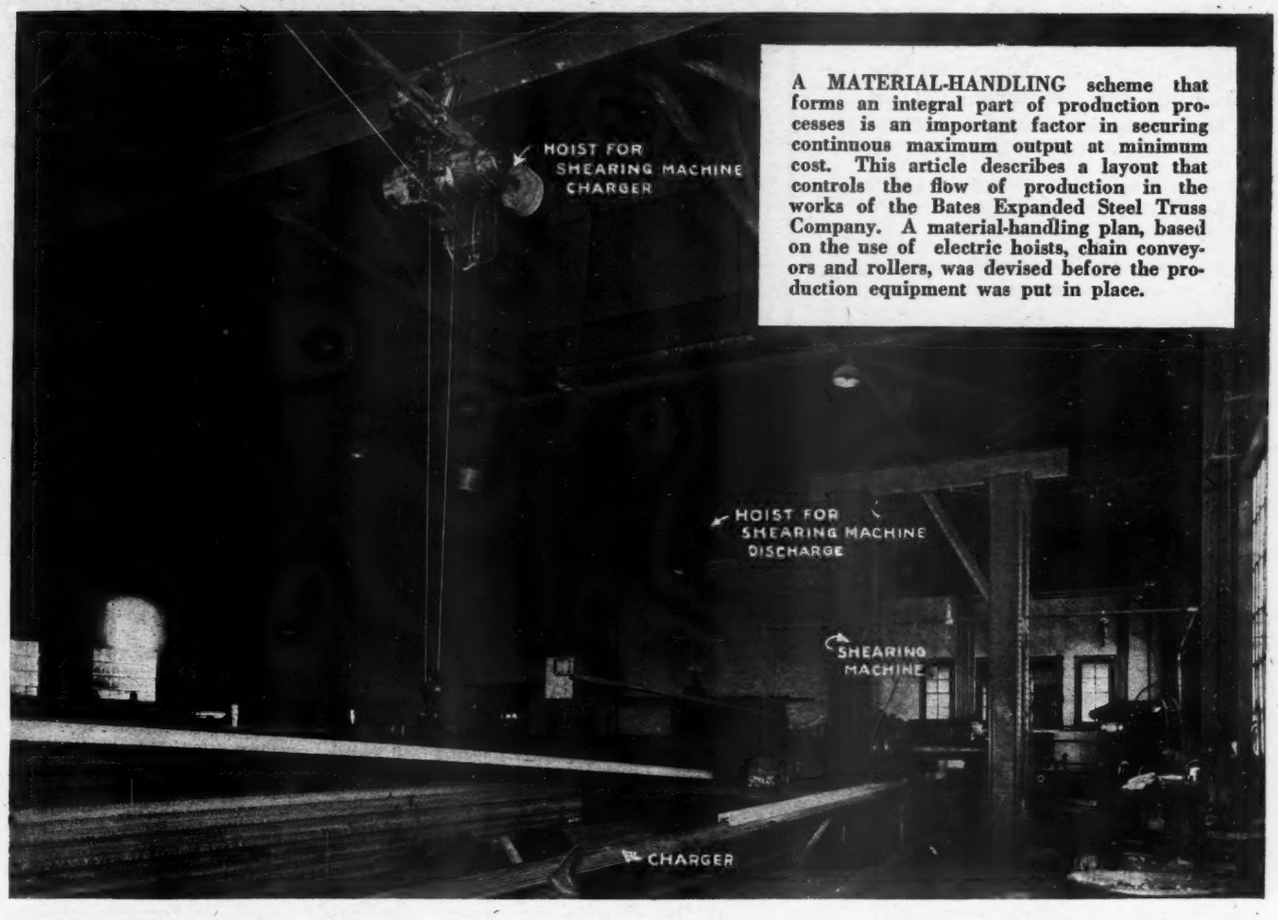

C L of pole
A- Single-phase Winding, Completely Distributed, With Full-pitch Coils
B-Same Chord Factor as A, But Higher Distribution Factor
C.L.of Pole
C-Same Distribution Factor as A, But Lower Chord Factor

Fig. 9—Single-phase winding for two poles in twelve slots using a completely distributed winding with full-pitch coils.
Fig. 10—Single-phase winding for two poles in twelve slots with one-third of the coils omitted to improve the distribution factor of the winding.
Fig. 11—Single-phase winding for two poles in twelve slots similar to Fig. 9 except having short pitch or chorded coils.



A MATERIAL-HANDLING scheme that forms an integral part of production processes is an important factor in securing continuous maximum output at minimum cost. This article describes a layout that controls the flow of production in the works of the Bates Expanded Steel Truss Company. A material-handling plan, based on the use of electric hoists, chain conveyors and rollers, was devised before the production equipment was put in place.

A floor-operated electric hoist is shown here placing a beam on the charging table of the shearing machine.

Here is an Instance Where

Material Moves With Production

And Handling Devices Tie Manufacturing Steps Into a Unit with Plant Expansion Effected by Adding Complete Units

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

IN MANY instances laying out a factory means placing the equipment and arranging the flow of raw materials and parts in process to conform with an existing building or group of buildings. An interesting example of a case where this process was reversed and the buildings were erected around the machines, is found at the works of the Bates Expanded Steel Truss Company, East Chicago, Ind. Here the various production processes are built around a material-handling scheme and the whole so closely interwoven that the entire plant functions as a complete unit to which no machine equipment can be added or taken away, all operations are on a time basis and the operators work with practically no supervision.

The principal product of this company is expanded steel poles for transmission line construction and the raw material is a special form of H-beam rolled for this purpose. These beams, which weigh between 250 and 1,000 lb. each and are from 20 to 35 ft. long, depending on the length of pole desired, are received on gondola cars on a siding at the rear of the plant. As will be seen from one of the accompanying illustrations, they are carried into the building and piled according to size and length by a 1-ton cage-operated, monorail electric hoist which travels on a beam running the full length of the building. The use of a lifting magnet for handling these beams was not found satisfactory inasmuch as it is impossible to pick out one beam from a pile with a magnet; therefore, a special grip was devised. This consists of an iron frame approximately 3 ft. long which is suspended from the hook on the hoist and is sufficiently narrow in the lower portion to slip between the flanges of the beam and rest on the web when the beam is lying on its side with the web horizontal. Close to the bottom and at each end of this grip there is a set of sharp steel points

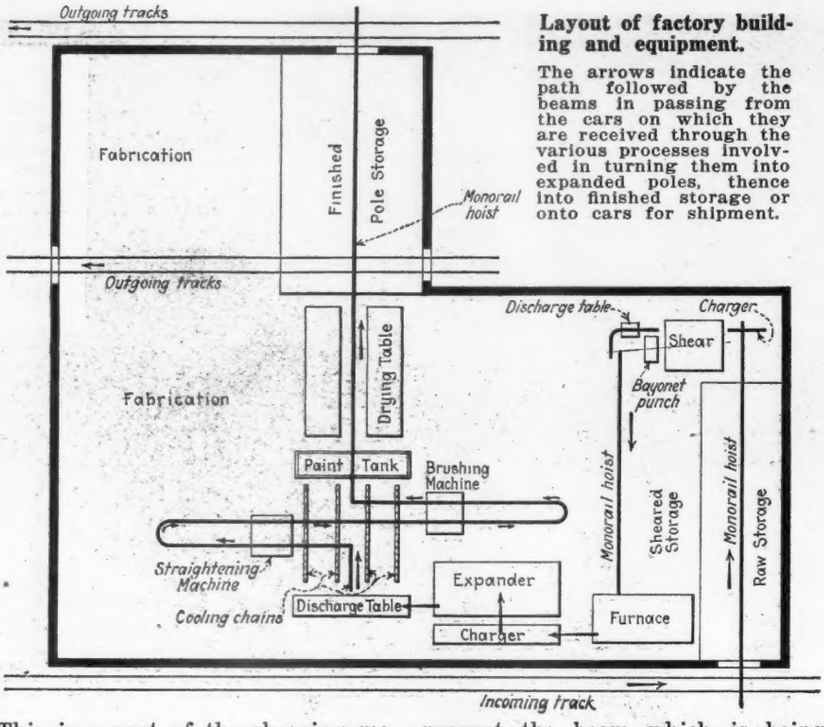
which move in and out and are controlled by the operator through a cam action. When the points are pushed out they are forced against the inner sides of the flanges of the beam so firmly that it can safely be lifted. In the case of floor-operated hoists the cam action of the grip is operated by a rod about 18 ft. long extending from the grip to the aisle. Gondola cars containing the beams are "spotted" so that the grip falls in approximately the center of the beam and the operator of the hoist can thus handle the beams from the cars to indoor storage without assistance.

From storage the beams are then moved as required to the shearing machine. In this case they are handled by a 1-ton Shepard floor-operated hoist equipped with the grip described above. The operator walks along an aisle formed by the wall of the building and the piles of beams and controls the hoist by remote control push buttons mounted in a small, especially designed case suspended from the hoist.

The shearing machine consists essentially of two revolving disks. The upper disk has continuous cutters.

The lower disk is 12 ft. in diameter, and has intermittent cutters and open portions called intacts so placed that when the beam is passed through the disks slits are cut in the web to allow the beam to be expanded, as will be explained later. The two disks are in effect a revolving punch and die.

As the beams are taken from storage they are placed on a narrow, charging table through which passes an endless chain fitted with dogs.



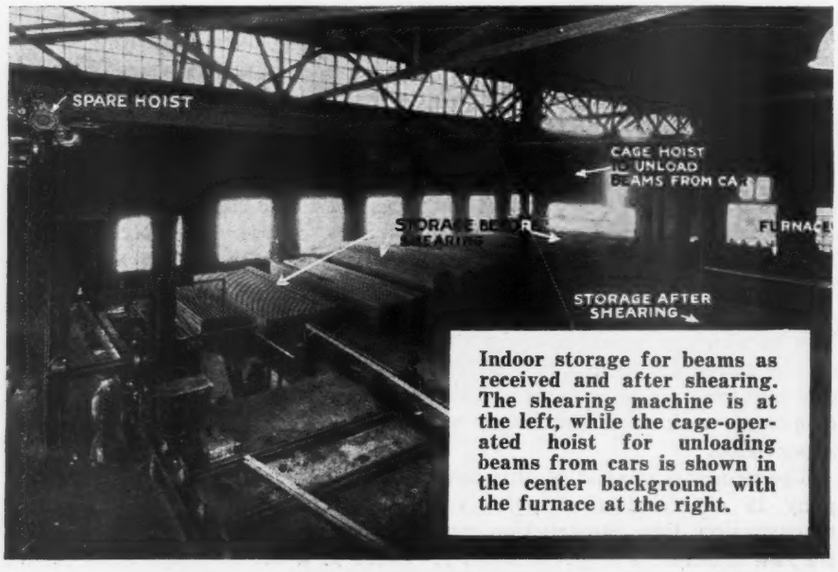
Layout of factory building and equipment.

The arrows indicate the path followed by the beams in passing from the cars on which they are received through the various processes involved in turning them into expanded poles, thence into finished storage or onto cars for shipment.

This is a part of the shearing machine and charges the beam through the shear. The disks revolve continuously but the driving mechanism of the chain is automatically controlled so that the beams are pushed between them at the right time to cut the slits in the proper position. This action is entirely automatic and beyond the control of the operator; he merely steps on a foot lever after the beam has been placed on the charger. Another feature of the automatic mechanical control of the shearing machine is that a beam cannot be charged into it until the last preceding beam has been removed from the discharge table. This is a fool-proof device to prevent the beam which is being sheared from pushing the previously sheared beam through the side of the building. After passing through the shear the beams pass out on a set of rollers which form a narrow discharge table. While they are on this table two holes for attaching a bayonet are punched in what will be called the upper end of the pole. From the discharge table the beams are picked up and moved either to sheared storage or direct to the furnace, where they are heated prior to being expanded. A 2-ton Shepard floor-operated electric hoist and grip is used for this handling.

The heating furnace is 36 ft. long and may be fired either by a battery of eight oil burners or by sixteen artificial gas burners. The beams are deposited by the hoist on a table which runs the long way of the furnace and are pushed into it broadside by an hydraulically-driven charging device. They are removed one at a time from one end of the furnace. When one beam is taken out the operator pulls a lever which controls the furnace charger, and the beams on the table, and those which are already in the furnace are automatically pushed forward just far enough to bring the next beam in front of the opening in the furnace end.

The beams are pulled out of the furnace one at a time and onto the table of the expanding machine charger by a steel cable which passes around one of two winding drums



Indoor storage for beams as received and after shearing. The shearing machine is at the left, while the cage-operated hoist for unloading beams from cars is shown in the center background with the furnace at the right.

The expanding machine transforms slitted beams into expanded poles.

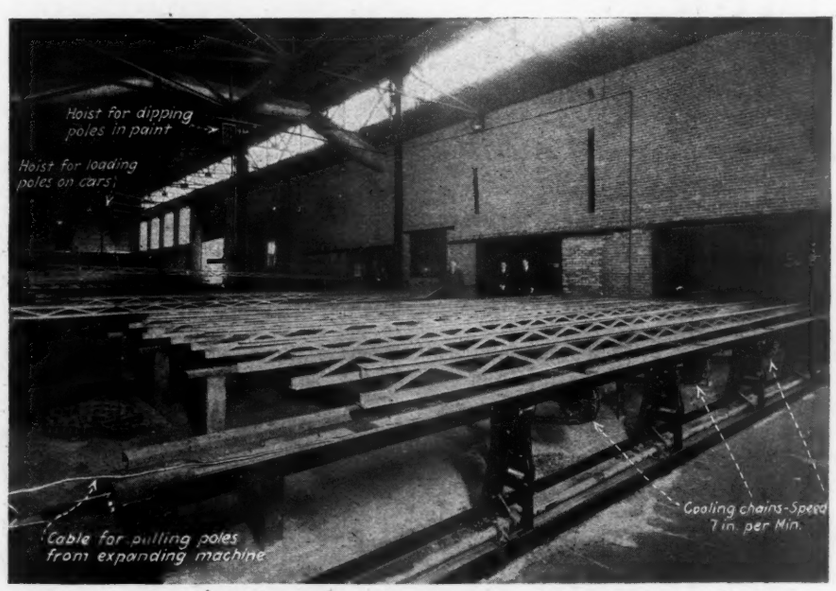
At the right, a red-hot beam is being pulled onto the expanding machine charger from the furnace, while an expanded beam or pole is being pulled from the expanding machine to the narrow discharge table from which it will be discharged onto the cooling chains at the right of the illustration. The expanding operation requires about two minutes and sets the pace for the other operations. The beams are pulled from the furnace and from the expanding machine by small steel cables which pass over two winding drums driven by a 3-hp. motor through two friction clutches. The operator at the left controls the action of the drums by the two levers shown.

which are driven by a 3-hp. motor and controlled by two Dodge friction clutches.

As the beams, which are heated to a temperature ranging from 1200 deg. F. to 1400 deg. F., are pulled out of the furnace onto the table of the charging machine, they rest on the flanges. The charger turns the beams through a 90-deg. angle so that they rest on one side and then pushes them between the jaws of the expanding machine. This expander consists in effect of an upper and lower set of parallel jaws approximately 36 ft. long. In the expanding operation the lower flange of the beam is gripped and held down by the lower set of jaws. The upper flange is likewise gripped by the upper set of jaws, which are capable of vertical movement and are raised by hydraulic power. In the manufacture of parallel-expanded beams both ends of the upper jaws are raised simultaneously and through the same distance. In making ordinary expanded poles, however, only one end of the upper set of jaws is raised, thus producing a tapering pole, the base of which is approximately 2½ times the width of the top. During the expanding process the web of the beam separates along the slits which were cut in the shearing machine, so that the final result is a pole consisting of what were the two flanges of the beam joined by the lattice-like truss portions of the web, which remain after the expanding process. The charger and expanding machine are controlled by one operator through a set of levers. The operation of these machines is practically automatic.

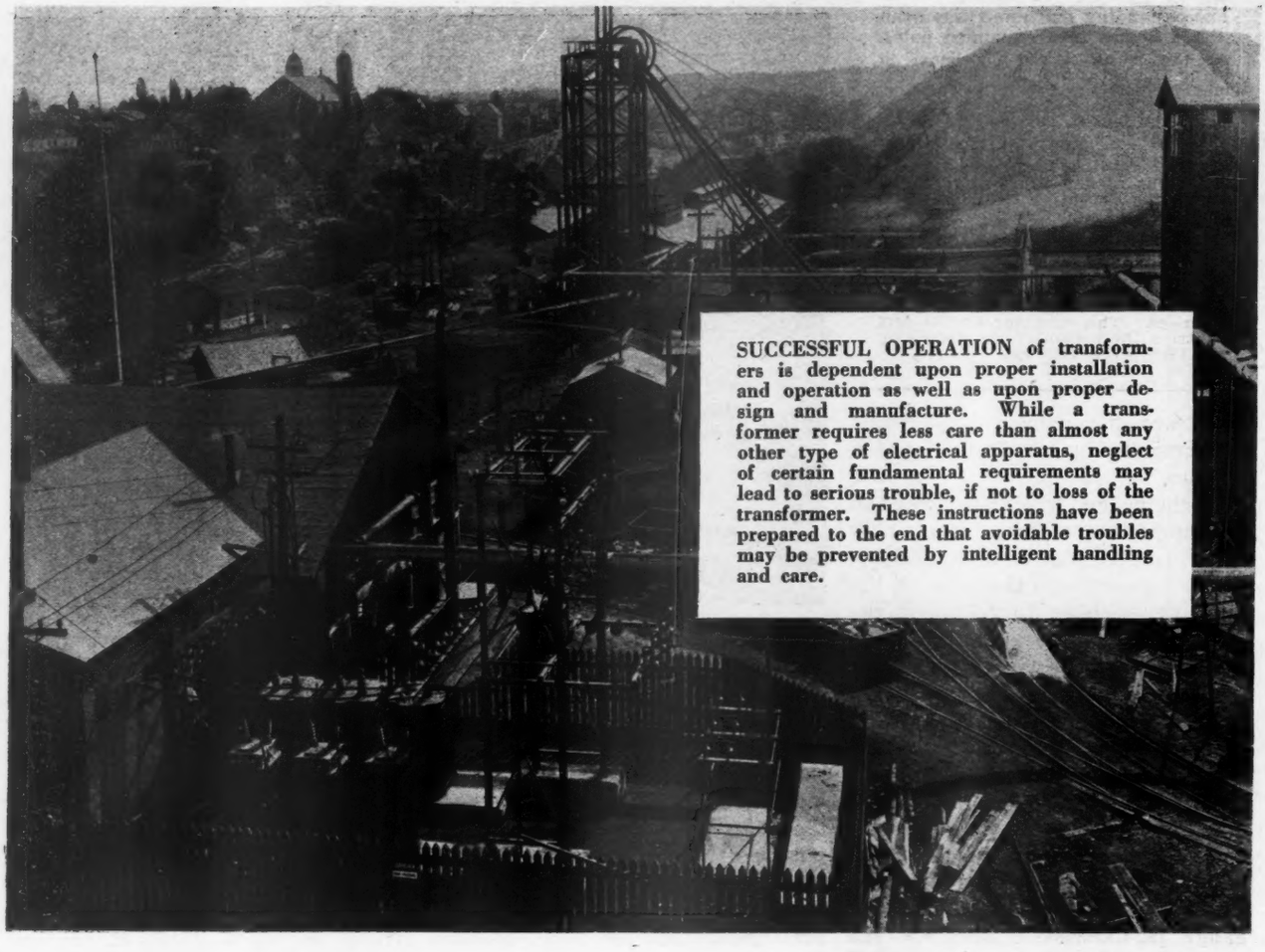
When the jaws of the expanding machine release, the expanded beams are drawn endwise onto a discharge table by a cable which passes over the second of the two winding drums mentioned previously. They are then discharged onto a set of four endless chains driven by a 3-hp. motor through spur and worm gears for speed reduction. These chains travel at the rate of 7 in. per min. and the poles are thus given time to cool to about 300 deg. F. before the next operation, which is straightening, or removing any crookedness which may have been caused by the preceding operations.

The poles, after traveling on one flange for about 25 ft. on the cooling chains, are rolled by hand over onto the other flange and onto 8-in. ball-bearing rollers, approximately 4 ft. long and placed parallel to the chains. They are then passed endwise to the left through the straightening machine. This machine is essentially a double "bulldozer," one on each side, working in opposite directions. When the bottom flange of a pole is straightened the pole is *(Continued on page 372)*


Hoist for dipping poles in paint
Hoist for loading poles on cars
Cable for pulling poles from expanding machine
Cooling chains-Speed 7 in. per Min.

The expanded poles are allowed to cool on slow-moving cooling chains on their way to the paint tanks.

These endless chains, of which there are four, carry the poles from the expanding to the straightening operation at a speed of 7 inches per minute. The operator in the center of the illustration has just tipped a pole from the chains onto ball-bearing rolls which are placed parallel and close to the cooling chains, preparatory to sending it to the left through the straightening machine, not shown here. From the straightening machine the poles are pushed on the rollers back across the cooling chains and through the door directly behind the operator of the floor-operated hoist to the brushing machine. From the brushing machine the poles are again slid onto the cooling chains, after which they are picked up by the 1-ton Shepard hoist shown at the left, dipped in paint, and placed on a drying table. Here they are picked up by one of the two 3-ton cage-operated electric hoists shown on the left and placed in indoor storage or loaded on cars for shipment.



SUCCESSFUL OPERATION of transformers is dependent upon proper installation and operation as well as upon proper design and manufacture. While a transformer requires less care than almost any other type of electrical apparatus, neglect of certain fundamental requirements may lead to serious trouble, if not to loss of the transformer. These instructions have been prepared to the end that avoidable troubles may be prevented by intelligent handling and care.

This is a 22,000-volt steel tower substation at Leggitts Creek Anthracite Company, Scranton, Pa. Three transformers have a rating of 250 kva., 22,000 volts to 440 volts, and three are rated at 333 kva., 22,000 volts to 220 volts. At present electrical equipment is installed for a third bank of three 500-kva., 22,000- to 2,200-volt transformers. The high-tension outdoor metering equipment is mounted on a platform in the steel tower.

Recommendations of Electric Power Club for

Care and Operation of Power Transformers

From the Standpoint of Those In Charge of Their Installation and Maintenance

GENERAL instructions for the care and operation of power transformers have just been prepared by the transformer section of the Electric Power Club and published for the use of operating and maintenance engineers. These instructions apply primarily to power transformers (sizes above 200 kva.) but they also apply to distribution transformers (sizes 200 kva. and smaller) in the higher voltage classes.

It is recognized that transformers are given less care than apparatus having moving parts; nevertheless, the neglect of certain fundamental requirements may lead to serious troubles if not to the loss of the transformers. Such fundamental maintenance and operating instructions have been covered in the recommended procedure prepared by the Electric Power Club. These instructions are given in full in what follows. They can be secured in pamphlet form from the Executive Secretary of the Electric Power Club, Keith Building, Cleveland, Ohio, or from the following member companies of the transformer section: Allis-Chalmers Mfg. Company, Milwaukee, Wis.; American Transformer Company, Newark, N. J.; Duncan Electric Mfg. Company, Lafayette, Ind.; Enterprise Electric Company, Warren, Ohio; General Electric Company, Schenectady, N. Y.; Kuhlman Electric Company, Bay City, Mich.; Moloney Electric Company, St. Louis, Mo.; Packard Electric Company, Warren, Ohio; Pittsburgh Transformer Company, Pittsburgh, Pa.; Wagner Electric Corporation, St. Louis, Mo.; Westinghouse Electric & Mfg. Company, E. Pittsburgh, Pa.

This is the first set of instructions, aside from the Industrial Control Handbook, that has been compiled

by the Electric Power Club on the care and operation of apparatus. It is planned to issue similar instructions on other apparatus within the scope of its activities. Another practical pamphlet prepared by the transformer section and issued in pamphlet form, covers transformer standards. A revised edition of this will be available in the near future.

LOCATION

Accessibility, ventilation and ease of inspection should be given careful consideration in locating transformers.

Water-Cooled Transformers depend almost entirely upon the flow of water through the cooling coils for carrying away heat so that the temperature of the surrounding air has little effect upon that of the transformers. For this reason air circulation is of minor importance and water-cooled transformers may be located in any convenient place without regard to ventilation.

Self-Cooled Transformers depend entirely upon the surrounding air for carrying away their heat. For this reason care must be taken to provide adequate ventilation. For indoor installation the room in which the transformers are placed must be well ventilated so that heated air can escape readily and be replaced by cool air from outside. They must be so located that water cannot fall on the tanks or rain blow upon them, if of the indoor type.

Self-Cooled Transformers should always be separated from one another and from adjacent walls, partitions, etc., in order to permit free circulation about the tanks. This separation should not be less than 24 inches to 36 inches, depending on size.

When the transformer can be set up immediately in its permanent location and filled with oil, it is advisable to do so, even though it will not be put into service for some time. If this is not convenient it should be stored in a dry place, having no rapid or radical temperature changes, and if possible, immersed in dry transformer oil. The transformer should not be stored or operated in the presence of corrosive gases such as chlorine, etc. If stored *OUTDOORS*, it should be thoroughly covered to keep out rain.

When lifting a transformer, the lifting cables must be held apart by a spreader to avoid bending the lifting studs or other parts of the structure.

Where a transformer cannot be handled by a crane, it may be skidded or moved on rollers, but care must be taken not to damage the base, or tip it over. A transformer should never be lifted or moved by placing jacks or tackle under the drain valve, cooling coil outlets, radiator connections or other attachments. When rollers are used under large transformers, skids must be used to distribute the stress over the base.

INSTALLATION

When working about a transformer particular care must be taken in handling all tools and other loose articles, since anything metallic dropped among the windings and allowed to remain there may cause a breakdown.

When shipped by the manufacturer, transformers are in first class operating condition. That is, they have been thoroughly tested for defects and are perfectly dry.

When received, examination should be made before removing from cars and if any injury is evident or any indication of rough handling is visible, railroad claim should be filed at once and manufacturer notified.

Moisture may condense on any metal if the metal is colder than air, and if present, it lowers the insulation properties and may cause failure of transformer. Therefore, if transformers or oil drums are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and they are thoroughly dry.

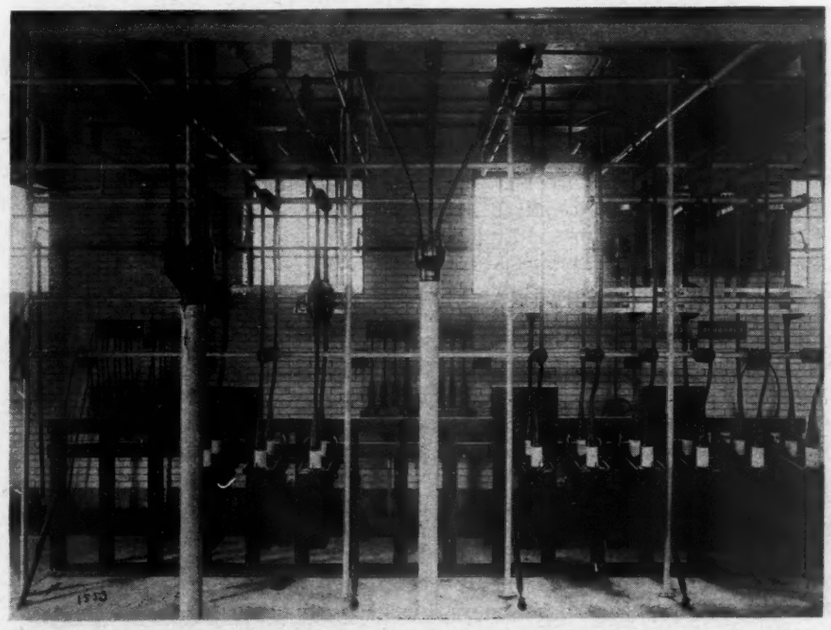
Before being set up, a transformer should be inspected for breakage, injury or misplacement of parts during shipment, and thoroughly examined for moisture, and all accessible nuts, bolts and studs should be tightened.

If transformers are water cooled, test the cooling coils for leaks, at a pressure of 80 to 100 lb. per sq. in. Water, oil or preferably air, may be used in the coil for obtaining the pressure. The coil must be outside of the tank, that is away from the coil insulation if water is used for the pressure test. When pressure is obtained, disconnect the supply and after one hour determine whether any fall in pressure is due to a leak in the coil, or is in the fittings at the ends of the coils.

Transformers Shipped Filled With Oil.—Each transformer shipped filled with oil should be inspected to see whether there is any condition indicating the entrance of moisture during shipment.

If the transformer is received in damaged condition, so that water or other foreign material has had a chance to enter the tank, the transformer should be emptied of oil and treated as though not shipped in oil, and in no case may drying be omitted.

In all cases samples of oil should be taken from the bottom and tested. The dielectric strength of the oil when shipped is at least 22 kv. be-



This photograph shows a section of a 6,600-volt indoor substation of the Eastman Kodak Company, Rochester, N. Y.

tween 1-in. disks spaced 0.1 in. apart. A new transformer should not be put into service with oil which tests below this value.

Transformers Shipped Assembled Without Oil. — Each transformer shipped assembled but not filled with oil should be carefully inspected for damage in shipment. A thorough inspection can only be made by removing core and coils from the tank. All dirt should be wiped off and parts examined for breakage or other injuries. All conductors and terminals should be examined to check their proper condition and position. Tighten coil and core clamps if necessary.

The tank should be inspected and, if necessary, cleaned.

When a transformer is shipped assembled but not filled with oil, moisture may be absorbed during transportation. For this reason it is good practice to dry out all such transformers, especially transformers above 7,500 volts before they are put into service.

Transformers Shipped Disassembled.—Only very large transformers are shipped in this way, and special instructions covering features incident to this method of shipping are supplied by the manufacturer. These instructions should be carefully followed.

Drying Core and Coils

There is a number of approved methods of drying out transformer core and coils, any one of which will be satisfactory if carefully performed. Too much stress, however, cannot be laid upon the fact that if carelessly or improperly performed, great damage may result to the transformer insulation through overheating.

The methods in use may be broadly divided into two classes: First, drying with the core and coils in the tank and filled with oil, and second, drying with the oil removed. In the latter case the core and coils may or may not be removed from the tank.

Under the first class, the moisture is driven off by sending current through the winding while immersed in oil, with the top of the tank open to the air, or some other arrangement made for adequate ventilation. This may be done by (1) the short circuit method (to be used if the transformer is new or has been out of service without oil any length of time). (2) Normal operation method (to be used if the transformer is already in service but shows moisture condensation and the transformer cannot be shut down to apply the short circuit method).

Short Circuit Method With Oil.—This method consists in heating the windings and oil up to a high temperature for a limited time under short circuit with a partial load on the windings, the high oil temperature being obtained by blanketing the tank (or reducing the flow of water for water-cooled transformers). In using this method, if the load does not exceed one-half or three-quarters full load, the winding temperature is not greatly in excess of the maximum or top oil temperature, so that high oil temperatures are safe without resulting in any deterioration of the insulation from local over-heating. With good ventilation, the moisture, as it is driven off in the form of vapor will escape to the outside atmosphere and no condensation of moisture will take place on the underside of the cover or elsewhere in the tank.

The following table shows the short circuit current in per cent of full load current which may be used, for this method of drying transformers, with the corresponding maximum allowable top oil temperature in degrees centigrade.

Short Circuit Amp. in Percent of Full Load		Maximum Top Oil Temperature
Self Cooled Transformers	Water Cooled Transformers	
50	50	85° C.
75	60	80° C.
85	75	75° C.

These temperature limits and loads must be strictly adhered to in order to obtain the desired results without danger to the transformers.

It should be noted that the higher allowable temperatures go with the smaller loads, that is, more blanketing or less water will be required for the smaller loads than for the higher in order to bring the oil temperature up to the point shown in the table.

Ventilation.—During the drying run, additional ventilation to that ordinarily provided should be maintained by slightly raising the manhole cover and protecting the opening from the weather.

When to Discontinue Drying.—Dielectric tests of oil samples from the bottom and top of the tank should be made twice daily while the transformer is hot. As soon as successive tests over a period of 24 hours (with the oil maintained at maximum temperature, *AND WITHOUT TREATING WITH THE FILTER PRESS*), show that the oil has met a test of 22 kilovolts with 1-in. discs set 0.1 in. apart, the drying run may be discontinued.

Another check on the effectiveness of the drying is to close up the ventilating holes and operate in this manner for 24 hours at the maximum oil temperature, chill the manhole cover, and then open and examine for condensation.

Normal Operation Method.—This method consists in providing ventilation in the cover, as explained above, and blowing air across the top oil, say by a desk fan, while the transformer is under normal operation.

Inspect the manhole cover frequently and raise the oil temperature by blanketing the tank or increasing the load. If condensation appears on the under side of the manhole cover, reduce the oil temperature and run until moisture disappears, then raise the temperature again.

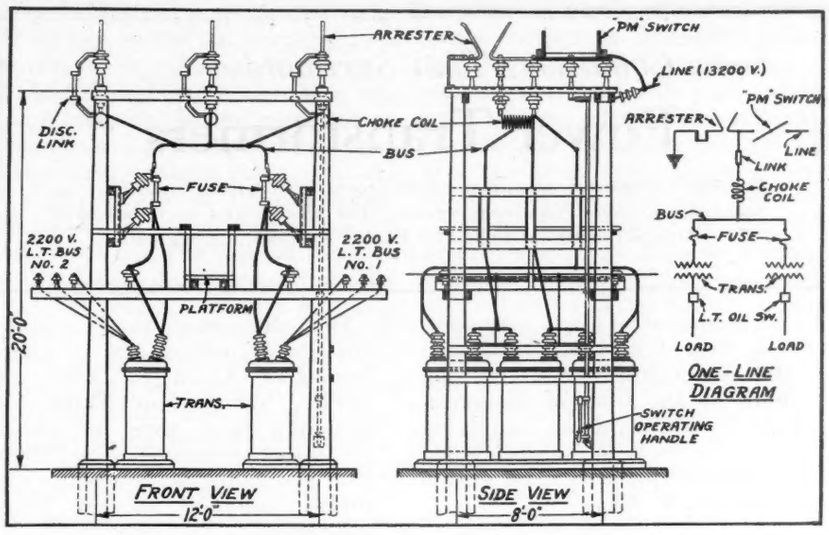
The following table will show the highest permissible load current for maximum top oil temperatures of 70, 75 and 85 degrees:

Load Amp. in Percent of Full Load		Maximum Top Oil Temperature
Self Cooled Transformers	Water Cooled Transformers	
50	50	85° C.
85	75	75° C.
100	85	70° C.

Continue for three days at maximum temperature; then if no condensation occurs, drying may be discontinued as outlined above in the paragraph "When to Discontinue Drying."

Typical of the second class, i. e., drying with the oil removed, are the three following methods: (a) by internal heat, (b) by external heat, (c) by internal and external heat.

(*a*) *By Internal Heat.*—For this method alternating current is required. The transformer should be placed in its tank without the oil and the cover left off to allow free circulation of air. The low-voltage winding should be short circuited and sufficient voltage impressed across the high-voltage winding to circulate enough current through the coils to maintain the temperature at from 75 deg. to 80 deg., centigrade. About one-fifth of normal full-rated current is gen-



Plan of out-door substation with common high-tension switching and lightning arrester equipment for two separately fused transformer banks supplying independent loads.

erally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers, but will generally be approximately one-half per cent to one and one-half per cent of normal voltage, at normal frequency.

The end terminals of the winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat in series with the exciting winding.

This method of drying out is superfiicial and slow and should only be used with small transformers, and then only when local conditions prohibit the use of one of the other methods of drying out described here.

(*b*) *By External Heat.* — The transformer should be placed in a wooden box with holes in the top and near the bottom to allow air circulation. The clearance between the sides of the transformer and the box should be small so that most of the heated air will pass up through the ventilating ducts among the coils and not around the sides. The heat should be applied at the bottom of the box.

The best way to obtain the heat is from grid resistors, using either alternating or direct current. The temperature limits are the same as for method *(a)*. The transformer must be carefully protected against direct radiation from the heaters. Care must also be taken to see that there is no inflammable material near the heaters, and to this end it is advisable to completely line the wooden box with asbestos.

Instead of placing the heater inside the box containing the transformer, it may be placed outside and the heat carried into the bottom of the box through a suitable pipe. Where this plan is followed, the heat may be generated by the direct combustion of gas, coal or wood, provided that none of the products of combustion be allowed to enter the box containing the transformer. Heating by combustion is not advocated except when electric current is not available.

This method, while effective, requires a much longer time than method *(c)*.

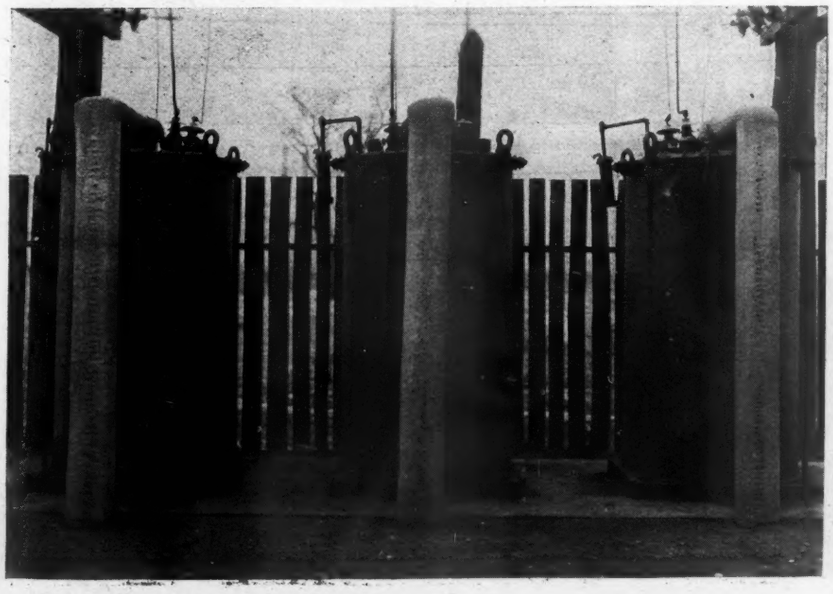
(*c*) By *Internal and External Heat.*—This is a combination of methods *(a)* and *(b)*. The transformer should be placed in a box and external heat applied as in *(b)* and current circulated through the windings as in *(a)*. The current should, of course, be considerably less than when no external heat is applied.

This method is used occasionally where direct current only is available, a certain amount of current being passed through the high-voltage winding only, as the cross-sectional area of the low-voltage conductor is generally too large for it to be heated with an economical amount of direct current. The use of direct current for drying out is not recommended except where alternating current cannot be obtained. When this method of drying is used, temperature should be measured by increase in resistance.

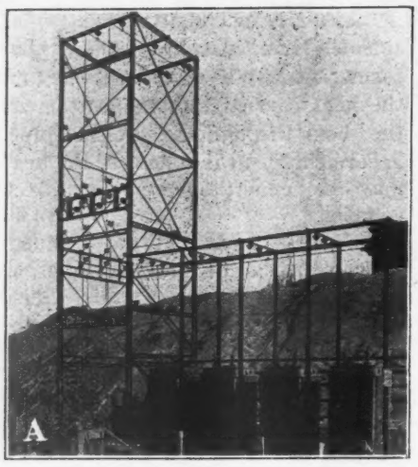
Method *(c)* is quicker than either *(a)* or *(b)* and has the great advantage that the insulation is heated much more uniformly.

Time Required for Drying.—There is no definite length of time for drying. One to three weeks will generally be required, depending upon the condition of the transformer, the size, the voltage and the method of drying used.

Insulation Resistance.—Insulation resistance is of value in determining the course of drying only when the transformer is without oil. If the initial insulation resistance be measured at ordinary temperatures, it



Water-cooled transformers rated at 833 kva., 60 cycles, 13,000-2,200 volts, on the lines of Harrisburg Light & Power Company, Harrisburg, Pa. These transformers are airtight and moisture proof. The water pipes are covered with asbestos to prevent freezing of the water in winter weather.

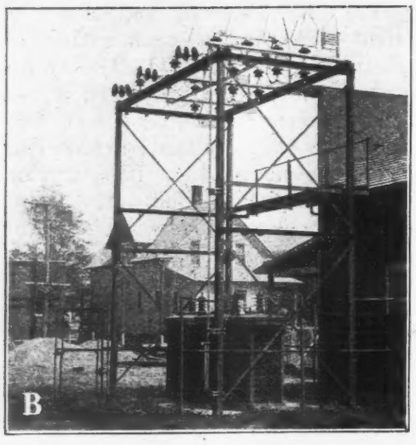


Some Conditions That Surround

Power Transformers

In outdoor industrial substations where proper installation, inspection and maintenance insure continuous service. The photographs were furnished through courtesy of Delta-Star Electric Company, Chicago, Ill.

A—Step-down steel tower substation with four 1,667-kva., 22,000- to 4,000-volt transformers with one spare on the lines of Monongahela Power Company, supplying power to the West Virginia Metal Products Company's brass mill at Fairmont, W. Va.



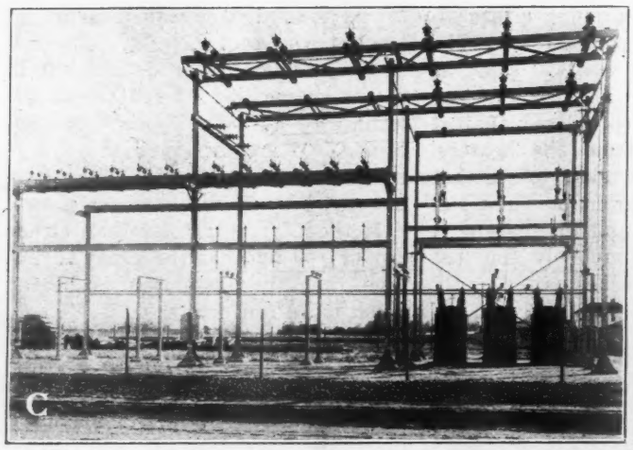
B—Steel-tower substation with a bank of three 200-kva., 22,000- to 2,200-volt transformers supplying industries in a small town.

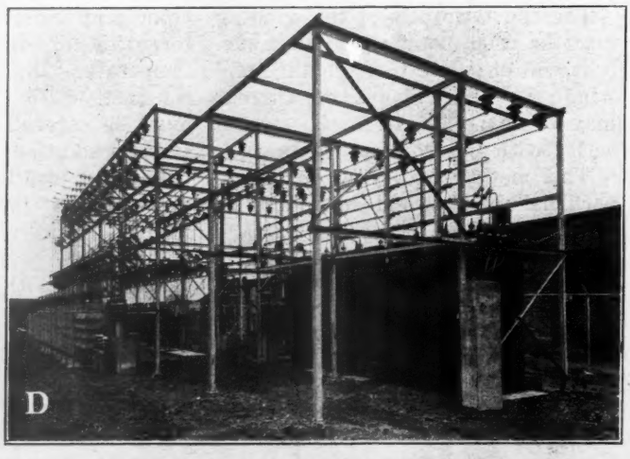
C—Combination switching tower and step-down substation with three 333-kva., 66,000- to 13,200-volt transformers, provision being made to add a future bank. This station is owned by the Arkansas Valley Railway, Light & Power Company, and is located at Fowler, Colo., supplying power to several towns and local industries.

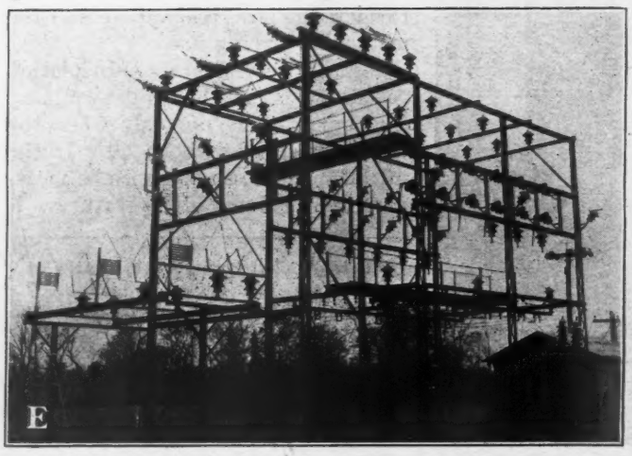
D—This photograph shows a combination switching and transformer station for 33,000-volt service, having four 33,000-volt incoming lines, three of which are direct connected to a 50,000-kva. generating station while the fourth supplies another large substation.

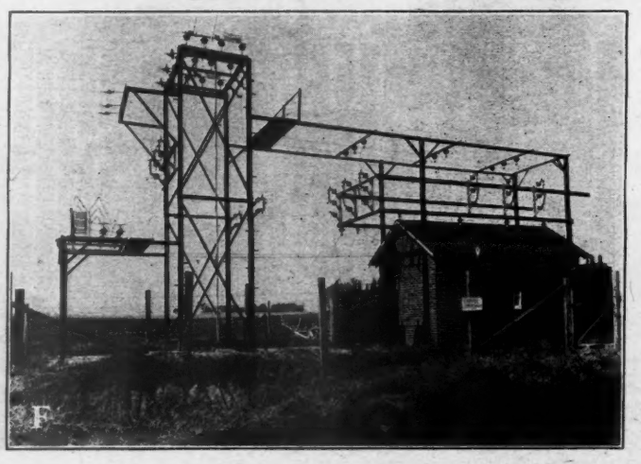
E—Steel-tower substation with four 3,300-kva., 66,000- to 4,000-2,300-volt transformers, and one spare, at a mine of the Wayne Coal Company, New Lexington, Ohio.

F—This station was designed to use six 400-kva., 16,200- to 440-volt, and three 75-kva., 13,200 to 2,300-volt power transformers, and one 10-kva., 2,300- to 110-volt lighting transformer. The high-tension metering equipment is placed below the main structure.









may be high although the insulation is not dry, but as the transformer is heated up, it will drop rapidly.

As the drying proceeds at a constant temperature, the insulation resistance will generally increase gradually until towards the end of the drying period when the increase will become more rapid. Sometimes the resistance will rise and fall through a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working its way out through the outer portions which were dried at first. As the temperature varies, the insulation resistance also varies greatly, wherefore the temperature should be kept nearly constant and the resistance measurements should all be taken at as nearly the same temperature as possible. The insulation resistance in megohms varies inversely with the temperature and for a 10 deg. centigrade change of temperature, the megohms change by a ratio of 2:1. Measurements should be taken every two hours during the drying period.

Resistance Curve.—A curve of the insulation resistance measurements should be plotted with time as abscissae and resistance as ordinates. By observation, the knee of the curve (i. e., the point where the insulation resistance begins to increase more rapidly) can be determined and the run should continue until constant for 12 hours.

Precautions to Be Observed in Drying Without Oil.—As the drying temperature approaches the point where fibrous materials deteriorate, great care must be taken to see that there are no points where the temperature exceeds 85 deg. centigrade. Several thermometers should be used and they should be placed well in among the coils near the top and screened from air currents. Ventilating ducts offer particularly good places in which to place some of the thermometers. As the temperature rises rapidly at first, the thermometers must be read at intervals of about one-half hour. In order to keep the transformer at a constant temperature for insulation resistance measurements, one thermometer should be placed where it can be read without removing or changing position. The other thermometers should be shifted about until the hottest points are found, and should remain at these points throughout the drying period. Wherever possible, the temperature should be checked by the increase of resistance method.

Caution.—It is well to have a chemical fire extinguisher or a supply of sand at hand.

It is not safe to attempt the drying out of transformers without giving them constant attention.

Sampling and Testing of Oil

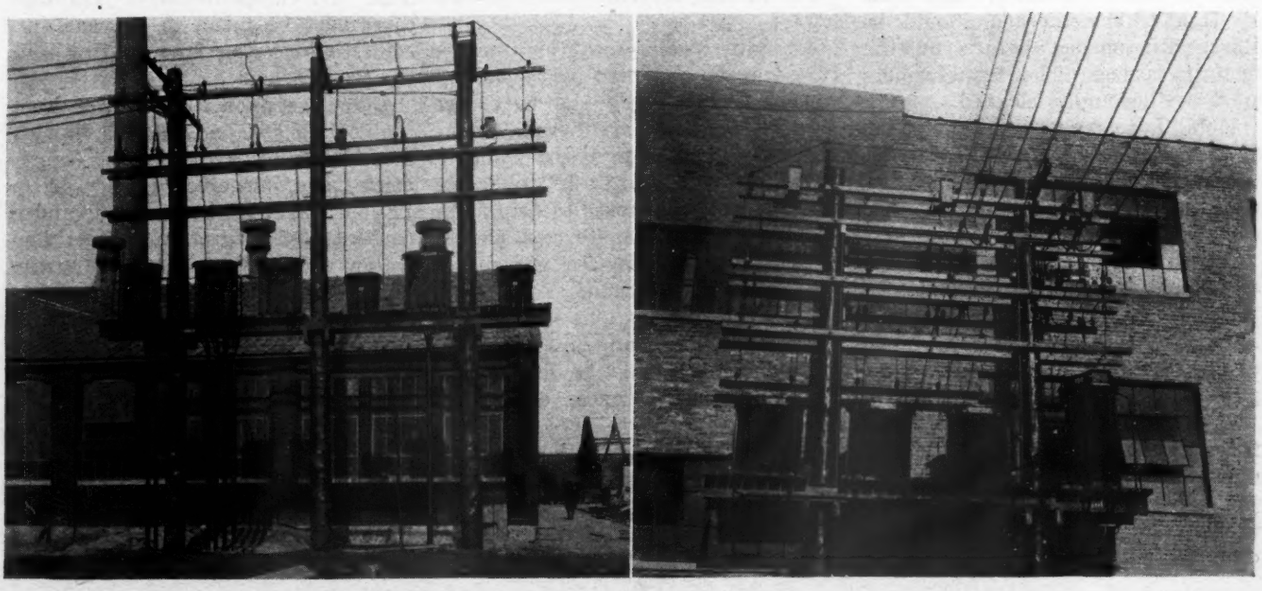
The sample container should be a large-mouth, glass bottle. All bottles should be cleaned and dried with gasoline before being used. Cork stopper should be used.

The sample for dielectric tests should be at least 16 oz., and if other tests are to be made, one quart (32 oz.).

Test samples should be taken only after the oil has settled for some time, varying from eight hours for a barrel to several days for a large transformer. Cold oil is much slower in settling and may hardly settle at all. Oil samples from the transformer should be taken from the oil sampling valve at the bottom of the tank. Oil samples from a barrel should be taken from the bottom of the drum. A brass or glass "thief" can be conveniently used for this purpose. The same method should be used for cleaning the "thief" as is used for cleaning the container.

When drawing samples of oil from the bottom of the transformer or large tank, sufficient oil must first be drawn off to make sure that the sample will be comprised of oil from the bottom of the container, and not from the oil stored in the sampling pipe. A glass receptacle is desirable so that if water is present, it may be readily observed. If water is found, an investigation of the cause should be made and a remedy applied. If water is not present in sufficient quantity to settle out, the oil may still contain considerable moisture in a suspended state. It should, therefore, be tested for dielectric strength.

Testing.—For testing oil for dielectric strength, some standard device for oil testing should be used. The standard oil testing spark gap has disk terminals one inch in diameter spaced one-tenth .inch apart. The testing cup should be cleaned



At the left, are three 75-kva., three-phase power transformers and two 40-kva. transformers for welding service, at a large industrial plant. The transformers for welding service are connected for single-phase on three-phase circuit. At the right, three 75-kva. three-phase power transformers and one 150-kva. single-phase lighting transformer.

thoroughly to remove any particles of cotton fibre, and rinsed out with a portion of the oil to be tested.

The spark gap receptacle should be nearly filled with oil and allowed to stand for a few minutes to give bubbles time to escape before making the test.

The rate of increase of voltage should be about 3 kv. per second. The average voltage of five tests is usually taken as the dielectric strength of the oil. Five breakdowns should be made on each filling, and then the receptacle emptied and refilled with fresh oil from the original sample. The test should be continued until the mean of the averages of at least three fillings are consistent.

The dielectric strength of oil when shipped is at least 22 kv. tested in the standard gap. If the dielectric strength of the oil in a transformer in service tests at less than 16,500 volts, it should be filtered. New oil of less than the standard dielectric strength should not be put in a transformer.

Drying Oil and Filling Transformer

In removing moisture from transformer oil, it is preferable to filter from one tank and discharge into another, although if necessary it may be drawn from the bottom of a tank and discharged at the top. When there is much water in the oil, it should be allowed to settle, then drawn off and moisture treated separately.

Filling Transformers.—Before the transformer is filled with oil, all accessories, such as valves, gages, thermometers, plugs, etc., must be fitted to the transformer and made oil tight. The threads should be filled with shellac before putting them in place. The transformers must be thoroughly cleaned.

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur found in rubber, and may cause trouble by the sulphur attacking the copper.

After filling the transformer, the oil should be allowed to settle at least 12 hours and then samples taken from the bottom should be again tested before voltage is applied to the transformer.

It is very important that the surfaces of the oil when cold (25 deg. C.) be at the oil level indicated by the mark on the oil gage. When the transformer is not in service, the oil level must never be allowed to fall to a point where it does not show in the gage. As the oil heats up with the transformer under load, it will expand and rise to a higher level.

First Time in Service.—When the voltage is first applied to the transformer it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be discovered before damage results. After full voltage has been applied successfully, the transformer should preferably be operated in that way for a short period without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days' service it is advisable to test the oil again for moisture.

Water Circulation.—If the transformer is water cooled, open the main water valve as soon as oil temperature reaches 45 deg. C. If there are two or more sets of cooling coils in parallel, adjust the valves of all sections for equal rates of flow. This can be estimated by feeling the weight of the discharge streams from the different sections. It can be determined best, however, by noting the difference in temperature between ingoing and outgoing water from each section. A careful measure should be taken of the total amount of water flowing through all sections and the total rate of flow adjusted to that called for.

Care

The idea that a transformer in service needs no attention may lead to serious results. Careful inspection is essential, and the directions given in this section should be followed.

In spite of all precautions, moisture may be absorbed by the transformer; and during the first few days of operation it is well to inspect the under side of the manhole cover for moisture. If sufficient moisture has condensed to drip from the cover, the transformer should be taken out of service and dried. The oil should be tested and dried if necessary.

Oil.—Samples of oil from all transformers should be drawn and tested at least once every six months.

During the first month of service of transformers having a potential of 40,000 volts or over, samples of oil should be drawn each week from the bottom of the tank and tested.

If at any time the oil should test below 16,500 volts, it should be filtered.

Inspection.—No matter how satisfactory the operation of a transformer may be, it should be taken out of service and thoroughly inspected at least once a year. See that the inside of the cover and the tank above the oil are clean and dry and free from moisture and that the thermometer bulb is clean. If an appreciable amount of dirt or sediment is found inside the case it is best to take the transformer out and remove the oil from the tank. The transformer and the tank should then be cleaned thoroughly and the oil filtered and tested. In cleaning, use only dry cloths or waste. See that all nuts are tight and all parts in their proper places. If the transformer is water cooled, clean the cooling coils thoroughly. Put the transformer and the oil in the tank again and when the cover is put on, see that all cracks and openings are closed tightly.

In the case of water-cooled transformers, the rate of flow should be checked from time to time and if it is found to have diminished the cause should be looked for and remedied. The most frequent cause of clogging of cooling coils is the presence of air in the water, resulting in the formation of a scaly oxide.

Removing Scale From Cooling Coils.—Scale and sediment can be removed from a cooling coil without removing the coil from the tank. Both inlet and outlet pipes should be disconnected from the water system and temporarily piped to a point a number of feet away from the transformer, where the coil can be filled and emptied safely. Especial care must be taken to prevent any acid, dirt or water from getting into the transformer.

Blow or syphon all the water from the cooling coil and then fill it with a solution of hydrochloric (muriatic) acid, specific gravity 1.10. (Equal parts of commercially pure concentrated hydrochloric acid and water will give this specific gravity.)

It may be found necessary to force this solution into the cooling coils. When this is done one end of the coil should be partially restricted, so that the solution will not be wasted when the coil is full. After the solution has stood in the coil about an hour, flush out thoroughly with clean water. If all the scale is not removed the first time,

repeat the operation until the coil is clean, using new solution each time. The number of times it is necessary to repeat the process will depend on the condition of the coil, although ordinarily one or two fillings will be sufficient.

The chemical action which takes place may be very violent and often forces acid, sediment, etc., from both ends of the coil; therefore, it is well to leave both ends partially open to prevent abnormal pressure.

Idle Cooling Coils.—When a water cooled transformer is idle and exposed to freezing temperatures the water must be blown out of the cooling coil. In addition to blowing out of the water the cooling coil should be dried by forcing heated air through it. If not convenient to do this the coil should be filled with transformer oil.

Operation

An artificially cooled transformer should not be run continuously, even at no load without the cooling medium. Therefore, it is essential to maintain a proper circulation in the cooling system.

If the water circulation is for any reason stopped, the load should be immediately reduced as much as possible and close watch kept of the temperature of the machine. When the oil at the top of the tank reaches 80 deg. C. the transformer must be cut out of service at once. This temperature should be recognized as an absolute limit and must not be exceeded. It should be held only during an emergency period of short duration.

Nearly all cooling water will, in time, cause scale or sediment to form in the cooling coil. The time required to clog up the coil depends on the nature and amount of foreign matter in the water. The clogging materially decreases the efficiency of the coil and is indicated by a high oil temperature and a decreased flow of water, load condition and water pressure remaining the same.

Temperature. — Thermometers should be read daily (or more often), and if an oil temperature of 80 deg. or over for the self-cooled type is indicated or 65 deg. or over for the water cooled, the transformer must be cut out of service at once and the cause of the excessive heating looked into, for should the transformer remain in service any length of time under this condition, it may be badly damaged.

Regardless of oil temperature as indicated by thermometers, the transformer must not be operated at overloads not stipulated by the specifications or contract. When contract specifies an overload, a water cooled transformer operated at such overload should have the amount of water increased in proportion to the load. On account of the increased amount of water during overload the temperature of the oil will not rise as fast as the temperature of the windings and any of the causes leading to excessive heating will have more pronounced effect under these conditions. Therefore, the transformer during overload should be watched with especial care to see that the oil temperature is kept well below the temperature limits specified. Moisture may get into a transformer due to the fact that as oil is heated and cooled it expands and contracts and therefore air is expelled from and enters the transformer. If the air which enters the transformer is at the same time cooled off by contact with cover to below its dew point moisture will condense.

It is therefore good practice to operate transformers several degrees above air temperatures at all times. This will largely prevent condensation.

Distribution and Chord Factors

(Continued from page 344)

altogether the resulting pole-phase effect v^1t^1 would be almost as great as xy from all six coils. Also in such a case the distribution factor would be represented by the expression:

(Line v^1t^1*)* $\div$ *(Arc vmt)* which approximates 0.8 and is a much better figure than 0.636 with all six coils in.

This explains why the majority of single-phase motors are wound with *concentric* coils and the middle of the pole is vacant, or if a distributed winding is used about one-third of the winding is omitted in a suitable manner. When the motor is of the *split-phase* starting type, the slots left vacant by the omission of a part of the main running winding (for reasons just given) are utilized for the *phase splitting* or *starting* winding and are mechanically in the right position to make the starting winding 90 space degrees out of phase with the running winding, which makes the mechanical relation of the starting to the running winding similar to the two windings of a two-phase, polyphase motor. Such an arrangement is shown in Fig. 7, where the full lines represent coils in the main or running winding, and the dotted lines represent coils in the starting winding, which are cut out of circuit by the starting switch as soon as full speed is reached by the rotor.

A winding such as that shown in Fig. 7 may have a distribution factor of 0.8 or higher, when considering the running winding alone, whereas the winding of Fig. 8, where all the slots are filled with the running or operating coils, may have a distribution factor as low as 0.636 for the reasons explained in connection with Fig. 6. In the case of Fig. 8, starting is accomplished by a commutator and brushes, or in some way other than by the split-phase principle. In this winding, although the two middle slots are not needed for a starting winding, it would be an advantage to leave them vacant, as in this way perhaps 20 per cent of the copper in the stator winding can be saved and the electrical or magnetic effect of the winding would be very little less, being something of the nature of the length of the line v^1t^1 in Fig. 6 as compared with the whole line xy.

Standard *diamond* coils of the type usually found in polyphase motors may also be used for single-phase. Such a winding is shown in Fig. 9 for a two-pole motor with twelve slots, having all slots filled and using all the coils for the running winding. In this figure the sides of the coils in the tops of the slots are shown in full lines, and the sides in the bottoms of the slots are shown in dotted lines. The *distribution factor* of such a winding would be low, being approximately 0.636 as explained in connection with Fig. 6. Here again, as in Fig. 8, it would be an advantage to omit the coils in the center of the poles and leave them vacant. Such a winding is shown in Fig. 10. With such an arrangement, if a split-phase starting winding was required on the same stator for some other job, the starting coils could be placed in slots 3 and 9 and 4 and 10.

One other feature of interest in single-phase distributed windings is the difference between *chord factor* and *distribution factor.* In Fig. 9 is shown a distributed winding whose coils *(Continued on page 371)*

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, July, 1923

Push! Pull! Or Get Out of The Way

IT IS said that the favorite motto of Jacob Kindleberger, president of the Kalamazoo (Mich.) Vegetable Parchment Company, is: "Push! If you can't push—pull! If you can't pull, please get out of the way!"

In every organization there are some who get ahead rapidly and there are others who wonder why. To those who wonder why Mr. Kindleberger's motto furnishes much food for thought. If you are a mechanic's helper or in charge of some particular work, there are plenty of opportunities to push or to pull and there are just as many opportunities to stand back and look on or knock the fellow who is pushing or pulling. But sooner or later you will look around to find someone saying, "Push or pull, or get out of the way!" and right there is your opportunity. If you don't push or if you don't pull—well, you'll just get out of the way, that's all!

Are You With a Wrecking Crew or Maintenance Men?

IN COMMENTING on maintenance work in one industrial plant, the superintendent referred to the men who handle emergency repairs as the "wrecking crew" and complimented them more as wreckers than "fixers," by adding: "And as often as not when they get through the machine is a wreck." Further investigation showed that in this plant only two qualifications were asked of these men: a strong back and the ability to fix anything, which in this case really meant "a desire to tinker and see what will happen."

Equipment, especially electrical equipment or highly complicated, specially designed production machines of the present day, is not fixed by the "tinkerer" of yesterday. He can easily make a mistake due to ignorance of the principles on which the mechanism operates, which will mean expensive repairs in addition to a shut-down which is perhaps more expensive in every way.

Men better qualified for the work—those with mechanical experience, such as all-around mechanics or men with a good working knowledge of electricity in its practical application to and operation of equipment—will, with an appreciation of their services, strive harder to make maintenance work a real thinking job. Men who think before they act like to be credited with applying their ideas; they want to be recognized as real maintenance men and not wrecking crews. It is difficult to have a higher appreciation of one's work than those in higher responsible positions credit to it—and right here a lesson can be taken to heart by those who supervise the men who do maintenance work.

The Foreman as a Teacher

EVERY successful foreman is a teacher whether he knows it or not and the one thing that contributes most to his success in the handling of men is his teaching instinct and ability. If you stop to think a little you can probably recall a mechanic or electrician who became so expert in his work that he was made a foreman. But simply because he did not have the patience to train beginners and others who knew less about the work than he did, he was soon relieved of his foremanship job or left to take another position.

Then there is the fellow who has the patience to show the beginner, but in showing him how to lay out or set up a job he does all the work himself and asks the beginner to watch him, without pointing out the steps in the work and explaining the many things that may happen if an error is made in any one of these steps. In such a case when the beginner makes a mistake he may be cussed out for it and commanded to keep his eyes open this time as the expert goes rapidly through the operations again. Such a foreman simply scares a young beginner and sets up a fear of doing something wrong that prevents the asking of questions that may bring a reprimand.

Then there is the third type of man, the one who makes the successful foreman—the man who remembers the troubles he went through as a beginner and knows how to combine telling and showing over and over again with a smile and some such remark as, "Try it again, my boy, and if you get stuck come to me and I'll help you out. When you have done this job as many times as I have you will be able to show me a better way to do it." Such a remark not only inspires initiative and confidence but trains a beginner to think. If he can be made to see the importance of thinking out each operation before he actually does it and avoid the "monkey-see-monkey-do" tendency, the foreman has solved the great secret of teaching and training workmen.

The next essential in teaching is observation on the part of the foreman to see how much the beginner absorbs when performing each step of a new job. One man can absorb and remember more than another and the foreman's big job is to see that he gets at least one thing right at a time and keeps on adding one thing after another so that he can be left to work out other similar details for himself in a reasonable length of time. But in every case it is the job of the foreman to continually drop the hows and the whys in the right place, for the things that are simple when you know

how and why to do them are not so apparent to the one who is starting in to do a kind of work that is entirely new to him.

Teaching has been called an art. In a workshop it is a great asset in a foreman for it reduces waste and increases the production of men as no other single thing can do. In a works where every job is done correctly and the foremen know how to bring this about, these foremen are the reasons for a successful shop and profits that pay good wages. On the other hand, those foremen who are known as crabs and walking evidences of irritation and poor digestion when things go wrong—and they go wrong frequently—these same foremen are one of the reasons for complaints from executives regarding high production costs and troubles with apparatus that is produced.

If you are a foreman think this over and study your job and your methods. Perhaps all that stands between you and a big job is a little more patience as a teacher and a little more thinking on your part as to how to make yourself a better teacher and get your men to come to you with their troubles. Just remember that you were a beginner once and appreciated a friendly tip from an experienced fellow-worker.

Decrease in Fire Loss of Electrical Origin

THOSE readers of INDUSTRIAL ENGINEER who take pride in doing a good job, will note with satisfaction an important decrease in the amount of fire loss attributed to electrical causes. Since the first introduction of electricity it has been cited as a fire cause of major importance, and rules to control its hazard were first established in 1881. These early rules have been improved upon and standardized and are now a part of the National Electrical Code. However, in spite of progressive improvements in electrical equipment and methods of installation, the annual losses reported as due to fires of electrical origin continue heavy. However, no complete loss analysis figures were available prior to 1915. In the period from 1915 to 1919, according to the National Board of Fire Underwriters, the loss from fires of electrical origin was over $84,000,000 or an average of nearly $17,000,000 per year. During this time, fires due to electrical causes, were the largest item among the classified losses due to known causes and amounted to about 15 per cent of the total, excluding those of unknown origin or those due to exposure and conflagration. Of course some fires were wrongly attributed to electrical causes purely on guesswork or inability to determine the real cause.

In the 1920 fire loss figures, as recorded by the National Fire Protection Association, "matches and smoking" displaced electricity as the most important fire cause. According to the 1921 statistics, electricity had taken fifth place with a total loss of $12,723,000, or a decrease of over $4,000,000 from the 1915-19 average. In addition, it is now responsible for only 8 per cent of the total loss as compared with 15 per cent of the loss for the earlier period.

That this loss has decreased in spite of the extensive increase in the use of electricity is in no small way attributable to the greater care exercised in the installation and supervision of electrical equipment and distribution lines. Pride in good workmanship in installation is no small factor in making this decrease.

The Best Cure for Trouble Is to Prevent It

IN THIS issue an article on page 348 gives some practical details on the care and operation of transformers from the standpoint of those who have charge of their installation and maintenance. These instructions have been compiled by the Transformer Section of the Electric Power Club—an organization of electrical manufacturers that has for its object the standardization, improvement of production and increase in distribution of electrical apparatus.

In these instructions one point is brought out that is frequently overlooked by men in charge of operation. This is that the successful operation of a transformer is as much and perhaps more dependent upon proper installation and maintenance than on proper design and manufacture. The works of a transformer are enclosed in a metal case and at times the things that go on inside that case while in operation, for instance during a thunderstorm, are often beyond the conception of the skilled transformer designer. But so long as there is voltage on the secondary winding the usual inference is that everything is O. K. And not until serious trouble shows up is that piece of electrical equipment given much attention.

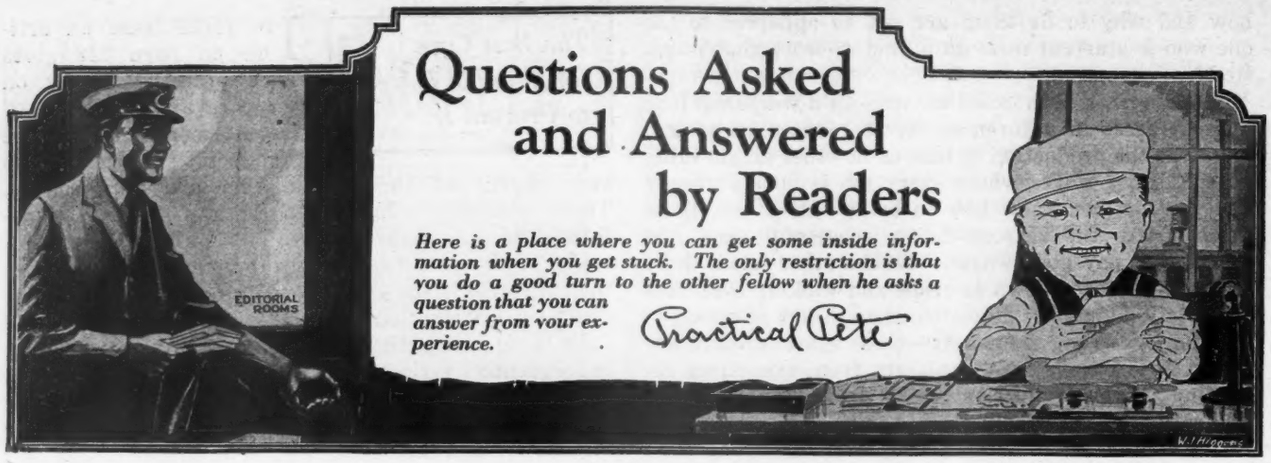
In the case of rotating apparatus this is not the case for signs of trouble can more easily be seen and even small troubles are watched and remedied at once. The same kind of attention should be given to a transformer and this attention should be directed toward location, handling, installation, inspection and testing of oil, and manipulation of loads put on transformers. These points are taken up in this article in such detail as will help to train men to get the best possible service from this apparatus with the minimum of trouble and work.

"Is It a Sign of Weakness to Seek Information?

WHEN trouble is traced back to the real cause it is altogether too often found that somebody tried to apply new equipment or methods without a clear knowledge of the limitations or modifications necessary for that particular service condition. This is partially due to an antiquated idea, which unfortunately still exists among many industrial men, that to ask questions is a sign of weakness. Rather, the ability to ask sensible questions is a good sign of balanced judgment.

In working up the article on "Types and Kinds of Chain Drives," which begins on page 335 of this issue, almost every manufacturer engaged in supplying chain drives urged that prospective users co-operate more closely with their engineering and manufacturing departments in the selection of the proper width, pitch, number of teeth in the sprockets and the other specifications for a particular job.

Investigation of several disappointments in chain-drive installations has shown that they were in a large measure due to industrial men applying a chain drive to service conditions to which that particular size and pitch was not adapted. Advice could have been obtained quickly from the manufacturer or his local representative and this grief and distrust in the equipment eliminated. It is easier to ask questions—and much cheaper—than to depend wholly upon experience.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Preventing Corrosion of Copper—Will someone please tell me how I can prevent the corrosion of copper parts of equipment that is located in a chemical plant. I have tried everything I can think of, but without success.

Charleston, W. Va. E. B. G.

* * * *

Rewinding Single-Phase Motor—I have a single-phase Menominee motor that has a main winding of 29 turns of No. 19 wire with two wires in parallel in slots 1 and 7. There are 48 turns in slots 2 and 6 and 49 turns in slots 3 and 5. This is a 4-pole machine.

The starting winding has 12 turns of No. 25 wire in slots 1 and 7; 20 turns in slots 2 and 6, and 20 turns in slots 3 and 5. What I want to know is whether or not this motor can be wound with a single wire and what size will be required to replace the two No. 19 size in parallel. The motor has 24 slots and the nameplate shows 110 volts, 3.8 amp. 1/6 hp., 1750 r.p.m. I have just rewound one of these motors with a single No. 19 wire and it seems to run all right.

Sartell, Minn. L. S.

* * * *

Connecting Lights and Small Motors to the Same Panel Board—I would like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting lights and fractional-horsepower motors to the same panel board. In our plant the incoming feeder is three-wire, three-phase, 110 volts a. c. We have five lighting circuits of approximately 600 watts and we have six motor circuits with a motor connected to each operating a ventilating fan. The motors are single-phase with the following ratings: two ⅛-hp., three ¼-hp. and one 1/16-hp.

I would like to see a diagram of a panel board arranged with a double bus to connect lights and motors separately, or any other arrangement which may be considered satisfactory. Please also indicate the way these circuits should be fused and the arrangement of switches for individual control.

Seymour, Conn. W. N.

Rewinding Universal Motor—I would like to rewind a Universal motor for three phases, 60 cycles, 220 volts, which has the following nameplate data: Type D, single phase, No. 14,840, 3,600 r. p. m., 220 volts, 60 cycles, 2 amps., ¼ hp. The motor has 24 slots and 8 coils of 56 turns of No. 19 B. & S. wire for the running winding. The other slots were used for the starting winding. What will be the size of wire, turns per coil and coil span for the new winding when operated three phase? There is very little end room so the coil span will have to be as small as possible. Please show how to figure out this winding and give a diagram.

Kimberley, Wis. H. D.

* * * *

Derivation of Chord Factor—(1) In his answer on rewinding a motor for four speeds, A. C. Roe says, on page 212 of the April issue: "Assuming a 1 and 12 pitch the chord factor is .99144. . . . . Then the voltage per turn for full pitch will be (127x1.009) divided by 104 . . . . . For a 1 and 10 pitch the chord factor is .92388, and full pitch voltage per turn equals (127 x 1.076) divided by 104 . . . ." I should like to know how the values 1.009 and 1.076 are derived, as the chord factor differs from the values given.

(2) In A. M. Dudley's book, "Connecting Induction Motors," there is given on page 187 the output coefficient values for 4, 8, 10, 12, 16, 20 and 24 poles. What values should I use for 2, 6, 10, 14, 18 and 20 poles?

Santa Barbara, Chihuahua, Mex. F. R. G.

* * * *

Rewinding Motor with Basket-Shape Coils—I shall appreciate it if some reader will give me some information about changing a motor winding. This is a Westinghouse motor, type CCL, 10 hp., 1420 r.p.m., 220 volts, 25 cycles, 3-phase, style No. 137022 A, serial No. 1585893. This motor was rewound with the so-called concentric winding and has eighteen coils of thirty turns of No. 13 wire, two wires in parallel, connected two circuit star. It is very difficult to rewind these motors with a concentric winding wherein the coils are wound full pitch. What changes would be necessary to wind this motor with basket-shape coils, reducing the coil throw and changing the connections?

Joplin, Mo. R. A. F.

Answers Received To Questions Asked

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?

Sartell, Minn. L. S.

The following will answer the question by L. S. in the March issue of INDUSTRIAL ENGINEER on how to figure the ampere rating of a cable. Referring to a table of allowable carrying capacities of copper wire, it is found that the area of No. 14 wire is 4107 circ. mils. Multiplying this by 7, the number of wires in the cable, we get 28,749 circ. mils. The table shows that No. 6 wire has an area of 26,250 circ. mils, and has a current rating of 50 amp., therefore, the cable has a rating of 50 amperes.

Boston, Mass. L. B. MORRILL.

* * * *

In reply to the question by L. S. of Sartell, Minn., in regard to the current rating of cables, I wish to call his attention to tables I and II, rule 18, of the National Electrical Code, where it is shown that the current ratings of stranded wires in table II are the same as the nearest equivalent solid wires.

Seven No. 14 wires make a cable with an area of 28,749 circ. mils, which is, of course, the sum of the areas of seven No. 14's each of 4107 circ. mils. The nearest equivalent area in solid wire is that of No. 6; consequently the current rating is the same as No. 6 solid wire.

This applies also to other sizes. For example, a cable consisting of 19 strands of No. 14 has a total area of $19 \times 4107 = 78{,}030$ circ. mils. The nearest equivalent in solid wire is No. 1 with an area of 83,690 circ. mils. and a current rating of 100

amp.; consequently, the 19 strands of No. 14 make a No. 1 cable with a current rating of 100 amp.

As the table of current ratings of solid and stranded wires are read down, it will be noted that they are practically the same for wires down to No. 0, and nearly the same for all others. E. A. GIBBS.

Boston, Mass.

* * * *

Trouble with Motor Generator—We have a 175-kva. motor generator set which is giving us trouble. The motor is a synchronous type operated at 2,200 volts. The generator is direct connected and produces 250 volts, d. c. The trouble we are having is with the a. c. motor. The stator and rotor of this machine have been rewound six times during the last year and a half. It carries a load of about two-thirds capacity but must and does handle 50 per cent overload for about two minutes over fifteen-minute periods. The generator is handling a load of mine locomotives and the overload occurs when the locomotives are taking the crest of a grade. However, the temperature rise of the machine at the end of a day's run is not higher than allowed by the manufacturer. The machine seems to be O. K. until it lets go, there being no evidence of slowing down. So far as we can ascertain, it seems as though the pole face winding gives way and this rips up both stator and rotor. The d. c. generator will not over-compound, even with all the shunt field cut out. I would like to see some explanation of the cause and remedy for this trouble.

Vincennes, Ind. T. J.

It occurs to me that T. J.'s trouble with his motor generator, as mentioned in the February issue, is similar to my experience with a 200 hp. synchronous motor operating at 2200 volts. This motor is used for a stamp mill drive, and is started by means of a 35-hp. induction motor and then thrown on the line with an automatic synchronizer. This motor carries about three-quarter load and the balance of its capacity is utilized for power factor correction and care is exercised to limit the machine current to the normal full-load current for the motor.

Following a burnout, an examination of the stator winding revealed several grounds at the point where the coils entered the laminations of the frame. A great majority of the coils were badly bent at this point, due to inadequate mechanical support. It was found that the automatic synchronizer did not function when the machine was in exact synchronism with the line, thus imposing a heavy strain on the motor windings and causing them to be bent at their weakest point, with consequent breakdown of the insulation.

More adequate support was given to the stator winding in the form of very stiff slot tubes, which protruded several inches from each side of the laminations. A more rigid binding of the winding and proper adjustment of the automatic synchronizer has prevented further trouble.

From T. J.'s description of his trouble, it would seem that the motor was subjected to occasional strains, rather than continuous overloading, which in time broke down the winding. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

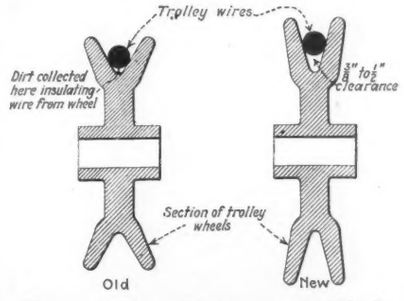
* * * *

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out; namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting devices.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?

New York, N. Y. M. K.

In the February issue I noticed the answer to a question by M. K. concerning trouble with a 5-ton alternating-current crane not getting the proper contact between the collector wire and the shoes or wheels. It reminded me of my experience with our a.c. foundry crane. I had trouble with the trolley wire and



How a trolley wheel was redesigned to improve the contact.

wheels day in and day out and finally discovered that the trolley wheel had collected a considerable amount of dirt which insulated it from the trolley wire. This was remedied by building a pattern and making a cast-iron deep-V wheel with about ⅜ in. to ½ in. clearance between the wire and the bottom of the V-groove in which the trolley wire runs. This put an end to all trouble. The deep groove allowed room for dirt so that it did not insulate the wire from the wheel. Also the wire crowds down into the groove thus keeping the sides clean.

Medina, Ohio. CARL NEWBRANDER.

* * * *

Contact Points on Electric Bells—What is the best metal other than platinum, to use for contact points on electric bells and gongs? If several kinds can be used, will you please indicate the order of their suitability, as first, second, third, etc.?

New Orleans, La. P. B. A.

In the May issue, P. B. A. asks what metals other than platinum may be used for the contacts of bells, gongs, and other instruments.

I have found that coin silver makes an excellent contact metal and in many cases is preferable to platinum. A small piece of silver wire about the size of No. 14 B & S gage can be purchased and when it is desired to make a contact point a very short piece can be placed in the hole in the contact spring and headed down on both sides. This will give an excellent contact for any kind of instrument. PERCY A. BLAISDELL.

Everett, Mass.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.

Hudson, N. Y. F. R.

With reference to the question by F. R. in the March issue, we would recommend by all means, that the operator be able to see the motor which he is starting. If you will give the matter a little thought it becomes evident that when starting large machinery various things may happen; so it finally becomes a question of safety and therefore a little expense should not be spared in arranging for the operator to have full vision of the machine which he is controlling.

We assume from the questions and from the information given that the starting equipment is manually operated, or in other words that it is not automatic control. If it were automatic control it would become a simple matter, inasmuch as the comparatively small control wires can be run to any desired point. However, if the motor is manually operated,

the power wires of necessity have to be run to the point where the starter is situated. Even so, we recommend that the starting equipment be arranged so that the motor is visible to the operator.

Automatic starting equipment for synchronous motors has been of late highly developed and we suggest that such equipment be seriously considered as it has many advantages over the manually-operated type. For instance, the control stations can be placed at any desired point inasmuch as it is not necessary to run the heavy power wires to these stations. There are also those features in automatic control which provide for absolute protection for the machinery and the operator, which cannot be had in manual control unless, of course, the operator is highly trained and knows the characteristics of the machines which he is operating.

Allen-Bradley Co., Milwaukee, Wis. W. PFEIFER.

* * * *

Why Does This Motor Reverse?—What would cause a 2-hp., d.c. compound motor, when a heavy load is thrown on, to reverse its direction of rotation? It can be started in one direction and then stopped and the next time it is started it may run in the opposite direction.

Toronto, Canada. J. H. M.

In answer to J. H. M.'s question in the January issue relative to a motor reversing when a heavy load is thrown on it, I believe that the field windings are differentially connected. When a heavy load is thrown on the machine a relatively heavy current flows through the series field winding, and if the differential connection exists, the flux produced by this heavy current becomes greater than that due to the shunt field winding and reverses the magnetism. This would cause the motor to run in the reverse direction. If it is now stopped and again started, lightly loaded, it will again reverse its rotation after the shunt field windings are differentially connetism to its former polarity.

I would suggest reversing the current through the series field so that the flux produced by both windings will aid each other, or, in other words, connect the motor cumulative; or a shunt could be connected around the series winding, obtaining the correct resistance by trial. In the latter case the motor would have characteristics resembling a shunt motor. I. J. GRONVOLD.

Tacoma, Wash.

The trouble with the compound motor mentioned by J. H. M., Toronto, Canada, is that the series fields and shunt field are connected so that they oppose each other. It will run in the direction the shunt field influences it while starting, but as soon as the heavy load is applied the series field picks up and overcomes the shunt winding effect and changes the direction of rotation.

Try disconnecting the shunt winding, then starting the motor with the series field only to note the direction of rotation it tends to give the motor. Be very careful not to let your motor run away. Just let it start and no more. No doubt you will find it tends to run in the opposite direction to what it did when starting with the shunt field connected.

Reverse the shunt field so that both windings are working together and reverse the armature if the motor should run the wrong way. Make this change and I am sure that your troubles will be over. I hope I have been of service and may need a hand from you some time.

Charleston, Wash. H. MCCONVILLE.

* * * *

The following will answer the question by J. H. M. of Toronto, Canada, as to why a d. c. compound wound motor will reverse when a heavy load is thrown on. The reversal happens because the motor is differentially compounded; that is, the shunt and series field instead of working together are working against one another and when a heavy load is thrown on the motor, the series field sets up a stronger flux than the shunt field. Therefore, the resultant flux, which determines the rotation of the armature, is in the opposite direction and the motor runs in the opposite direction.

This may be easily overcome by reversing the leads of the series field, which will reverse the direction of the current relative to the field, thereby causing the two fluxes to be in the same direction and the shunt and series fields will work together and give the proper characteristics of a compound motor.

NORMAN E. SMITH.

New York Shipbuilding Co., Westville, N. J.

* * * *

In regard to J. H. M.'s question in the January issue as to what makes a compound d. c. motor reverse on overload or at starting, he will probably find that the motor in question is differentially compounded. In that case a sudden load or a load at starting would cause the motor to reverse its direction of rotation especially if it is over-compounded.

The following procedure will reveal whether or not the motor is differentially connected. Start the motor up without load and while it is running open the shunt field. If it is differentially wound it will reverse its direction of rotation and run in the opposite direction at high speed. One must be careful in making this experiment to stop the motor at once as it will then be running as a series motor without load and a series motor without load will "run away."

If the motor is found to be differentially wound, the cure for the trouble will be to reverse the connections to the series field so the motor will be connected as a cumulative winding. This, of course, will change its characteristics slightly but the motor will operate all right.

D. A. BLODGETT.

Chevrolet Motor Co., Flint, Mich.

* * * *

In answer to J. H. M. regarding the reversing of a 2-hp. compound motor will say that I have had the same trouble and stopped it by reversing the series field leads, as the fields were bucking each other. On light loads the trouble did not show up, but with a good load on the motor would accelerate to about half speed, throw the belt off and race as an unloaded series motor.

H. G. LEONARD.

New Haven, Conn.

* * * *

J. H. M. desires to know why a 2-hp. compound-wound motor reverses its direction when a heavy load is thrown on. This is without a doubt due to the series fields bucking the shunt fields. The motor should be tried as a plain shunt wound motor and if this works alright, then reverse the compound or series fields and try it again. It is possible that only part of the series coils are opposed to the shunt winding.

To test the polarity of the fields first place a suitable amount of resistance in series with the compound fields and note the pole of a compass that each field attracts when the current is shunted across them. Then put the shunt fields across the line and check them with a compass. The shunt and series fields should agree as to polarity.

If a compound lead is taken for the line connection on the motor, care should be taken that the shunt, taken with the other lead to connect to the armature, comes from the same side of the same field. In our experience we have found that compound-wound motors will not always work properly with the compound lead for the line. The most successful way is to connect a compound and a shunt lead coming from the same part of the same coil for the line and then connect the other side of the compound to the armature. The other field and armature leads then go to the rheostat.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

With reference to the question by J. H. M. in the January issue of INDUSTRIAL ENGINEER, the reason the compound d.c. motor reverses under heavy load is that the series field is opposing the shunt field. When starting at practically no load, the shunt field provides the necessary field for the desired direction of rotation, but when fully loaded the series field provides a greater flux in the opposite direction and counteracting the shunt field flux, causing the reversal of the armature. If you reverse the series field connections you will experience no further trouble. E. H. LAABS.

Cutler-Hammer Mfg. Co.,
Engineering Department,
Milwaukee, Wis.

* * * *

In answer to the question by J. H. M., Toronto, Canada, as to the cause of a compound-wound motor reversing its direction when a heavy load is thrown on it, I will say that there are two kinds of compound-wound motors. One is differential wound, the other cumulative wound. I think he is speaking of the first type because it is extensively used.

The differential-wound motor has two sets of fields. The shunt field has a constant supply of current and is connected across the supply lines; the other, series field, is connected in series with the armature and has a magnetizing effect depending upon the pull of the armature or load applied to the motor.

It is clear that the current in the series field is reversed and opposed to the magnetizing effect of the shunt field. As the load is applied the magnetizing of the shunt field will be weaker than if the shunt field was alone. Then, if you now have a weakened shunt field because of shorts in the winding, bad connections in field or rheostat, or a complete open after the motor was up to speed, this would cause the motor to reverse its direction because just as soon as the series field has enough current to overcome the magnetizing effect of the shunt field, it will reverse itself. The weaker the shunt field, the more current the armature must have, therefore, the series field will be the stronger.

The motor also could be over-compounded; that is, it would have too many turns in the series field.

H. T. FOX.
Chief Electrician,
G. & J. Tire Co.,
U. S. Rubber Co.,
Indianapolis, Ind.

* * * *

I have found two instances similar to the one related by J. H. M. where the trouble was due to poor contact at field terminals on the starters. However, the trouble may also be the result of wrongly connected fields; that is, series and shunt fields have opposite polarities.

To test for this condition disconnect one side of shunt field, run as a series motor, and note direction of rotation. Do not cut out the starting resistance as the motor will overspeed. Now open the connection between armature and series field, reconnect the shunt field across the armature and start the motor. If rotation is reversed, the fields have opposite polarity. To remedy this cross either shunt or series connections whichever will give the desired direction of rotation.

Another way would be to take the speed of the motor compounded and then short circuit the series field and take the speed again. If the speed decreases, the fields are of opposite polarity.

It seems to me that if proper size fuses were used they would blow before the motor could reverse while heavily loaded. N. G. WILLEN.

Crocker-Wheeler Co.,
Ampere, N. J.

* * * *

J. H. M. wishes to know what causes his compound-wound d.c. motor to reverse its rotation under heavy load. This is most likely caused by the series fields being connected up to give an opposite polarity to the shunt fields. Of course under a light load there is very little current passing through the series coils and the polarity will not be affected. The current will, however, tend to deaden the shunt field, causing the motor to run above normal speed.

When a heavy load is put on the motor the series field is strengthened and overcomes the effect of the shunt field, changing the polarity of the field and, therefore, running the motor in the opposite direction.

The series field leads should be changed or swapped around where they are connected on the outside of the motor, without changing the other leads. If this cannot be done, owing to the series field leads not being brought outside of the motor, change the shunt leads around, outside of the motor and also change the armature leads where they are connected on to the brush holder studs. ELLIOTT M. GASKILL.

Foreman Electrician,
Wharton, N. J.
Mt. Hope Mines.

* * * *

NOTE: These several answers to the question by J. H. M. are presented because of their general agreement on the possibility of the shunt and series fields being of opposite polarity as now connected. And also because two or three refer to other points that are worth trying out at the same time the polarity is checked.—PRACTICAL PETE.

* * * *

Changing Speed of Single-Phase Motor—I have recently had trouble with a single-phase, 3-hp., 1200 r.p.m. motor which was marked Variable Speed on the nameplate. This motor has four brushes, two on compensating winding and two on the main winding, but seems to be a six-pole design. I would like to know how this motor can be changed to get a variation in speed.

Kings Park, N. Y. N. J. W.

From the question by N. J. W. of Kings Park, N. Y., it is evident that his motor is a repulsion induction motor of the brush-shifting type. It is probably a General Electric type B. S. S. motor. Of the four brushes, two are energy brushes and the other two are compensating brushes, which are connected to the compensating winding. It is necessarily a 6-pole design to obtain a synchronous speed of 1200 r. p. m.

The speed may be varied by loosening the brush yoke and shifting the brushes. A minimum speed of 600 r. p. m. at full load can be obtained. If this is a General Electric motor, the proper instruction book, which will give more complete information, may be obtained by writing to the nearest office of the General Electric Company. L. B. MORRILL.

Boston, Mass.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

Easily Constructed Portable Staging Facilitates Work on Overhead Equipment

A PORTABLE staging which we have used for several years when painting or doing electrical or millwright work, has saved so much time and been so useful that it may be of interest to the readers of INDUSTRIAL ENGINEER. As will be seen from the accompanying illustration the lower part of the first staging we made up was built of 2¼-in. seamless steel tubing, 7/32 in. thick, welded into malleable iron fittings. The upper part, which telescopes into the lower part, so that it can be raised or lowered as desired, was made of 1 15/16-in. seamless tubing 7/32-in. thick. Later it was found that black pipe could be used in place of the seamless steel tubing with equally satisfactory results.

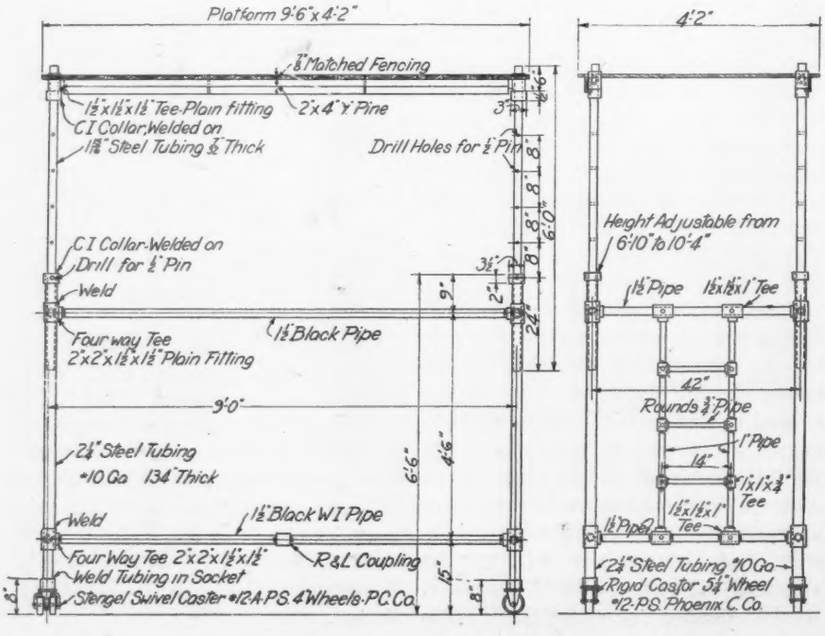
Holes large enough to take a ½-in. pin are drilled on 8-in. centers in the supports of the upper part of the staging to allow the platform to be set at any desired height. The platform at the top is made of ⅞-in. matched fencing, nailed onto pieces of yellow pine 2 by 4. It is made in three sections, which can be removed. The bottom rail is made of two pieces of 1½-in. pipe put together with a right-and-left-thread coupling. When working above machines this rail is taken out to allow the staging to straddle the machines.

The ladder at the end consists of ¾-in. pipe for the rungs and 1-in. pipe for the sides, screwed into malleable iron T's.

This staging is not expensive to make and is well worth its cost, as it permits overhead work to be done with the maximum of convenience and safety. L. B. C.

La Salle, Ill.

This staging furnishes a safe standing place for the installer or repairman.

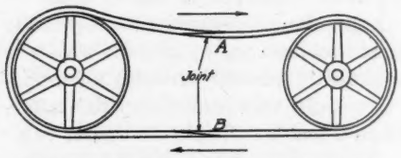

Platform 9'6" x 4'2"
⅞" Matched Fencing
1½" x 1½" x 1½" Tee-Plain fitting
C I Collar Welded on
1½" Steel Tubing ⅛" Thick
2" x 4" Y Pine
Drill Holes for ½" Pin
C I Collar-Welded on
Drill for ½" Pin
Weld
Four way Tee
2" x 2" x 1½" x 1½" Plain Fitting
1½" Black Pipe
9'0"
2¼" Steel Tubing
#10 Ga .134" Thick
Weld
1½" Black W I Pipe
Four Way Tee 2" x 2" x 1½" x 1½"
Weld Tubing in Socket
Stengel Swivel Caster #12-A-P.S. 4" Wheels-P.C. Co.
4'2"
Height Adjustable from 6'10" to 10'4"
1½" Pipe
1½" x 1½" x 1" Tee
42"
Rounds ¾" Pipe
1" Pipe
14"
1" x 1" x ¾" Tee
1½" x 1½" x 1" Tee
1½" Pipe
2¼" Steel Tubing #10 Ga
Rigid Caster 5" Wheel
#12-P.S. Phoenix C. Co.

Experience Shows How to Arrange Laps of Cemented Joints in Belts

WHEN the joint of a belt is to be cemented there is often a question as to the direction in which the laps of the joint should point. Common practice is to arrange the laps as shown in *A* of the illustration, so that the inner lap will point opposite to the direction in which the belt is to be run. The object of this is to prevent all possibility of the inner lap rolling up, which it might do if it met the pulley point on.

But with the inner lap so arranged, the outer one must point in the running direction. Consequently, when the joint is passing over a pulley and the outer lap is subjected to a bending stress which tends to open it, the point of the lap is running against the pressure of the air and is thus subjected to a disrupting force which may be greater than that which is due to friction against the face of the pulley. Hence, pointing the inner lap

in the running direction, as in *B*, would seem to be the better way. The superiority of this method was shown in the case of a 30-in. main



The question is often raised as to the direction in which the laps of cemented joints in belts should point. In the text there are given the results obtained with a belt having two joints in which the laps pointed in opposite directions.

belt running 3,500 ft., or nearly 0.6 of a mile, a minute. This belt contained two cemented joints. In one joint the inner lap pointed in the running direction. This joint never gave trouble. For some reason the other joint was made with the inner lap pointing away from the running direction. It was necessary to remake this joint frequently on account of a tendency of the outer lap to work loose and peel off.

St. Louis, Mo. A. J. DIXON.

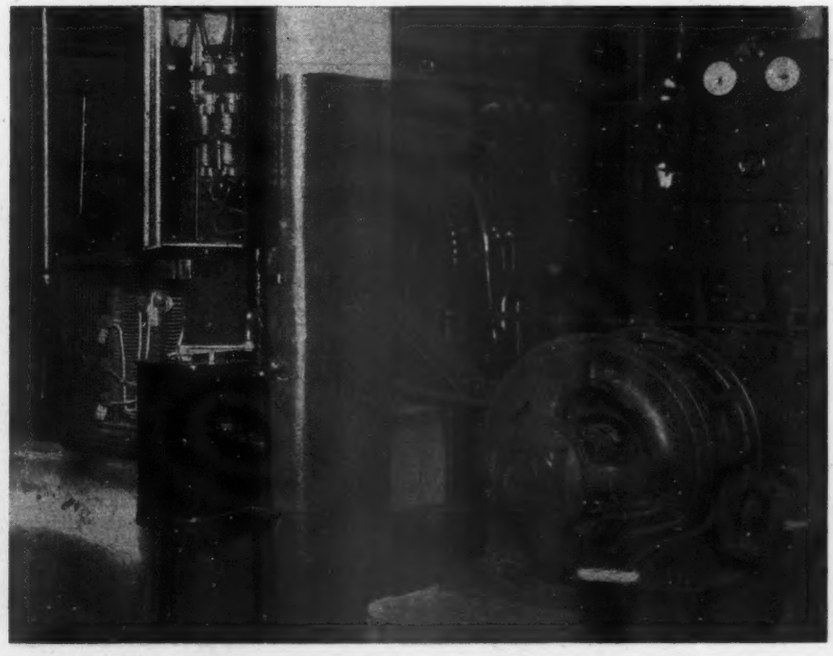
Simple Method of Mounting Starting Equipment for Motor on Column

WHEN a motor is located near a building column the latter can often be used to advantage for mounting the starting equipment in a very satisfactory and neat manner.

The photograph shows the method of mounting the control for a 50-hp. 440-volt, 900 r.p.m. slip-ring motor driving an air compressor. The 100-amp. line switch is mounted in a box directly over the drum controller on one side of the column. The feed to the switch box comes in an overhead conduit to the top of this box. The controller is mounted far enough away from the column to permit easy access to the terminals and allow sufficient room between the controller and the column for the conduit carrying the stator leads to pass behind it. The starting resistance is mounted on a side of the column at right angles to the controller, with the connection side of the resistance toward the connection side of the controller. This permits of a short connection, which requires no support, between the controller and the resistance. The rotor leads tap into these leads between the controller and resistance.

EUSTACE C. SOARES.

Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.



Here is a good installation—and a good way of utilizing a building column. The starting equipment is convenient yet mounted far enough away from the column to permit easy access to the terminals and allow sufficient room for the conduit.

Tests Made on the Use of Special Motors to Drive Fluctuating Loads

A MACHINE which has a fluctuating demand for power calls for special care in selecting a motor to drive it. The ordinary motor may not give the best results. It is often possible, however, to use motors with special features which will give very good operation.

These facts are particularly applicable to direct drive with alternating-current motors. There are many machines such as presses, punches, and so on, whose loads vary rapidly. Such loads as these can often be satisfactorily driven by an induction motor having a rotor with resistance higher than that of the ordinary rotor.

A very good example of such an installation is the motor driving a press from which the accompanying curves were taken. This drive shows the advantage that comes from the higher resistance in the rotor. The press mentioned is a Stohl press used for making 7-ft. fence posts of 14-gage material. Tests were made using an ordinary motor and a motor with higher resistance in the rotor. The two curves show the results. A 20-hp. motor was employed in each case and the press was doing exactly the same kind of work.

The curve at the left shows the variation in power when the press is operated by a motor of the ordinary low-resistance-rotor type. Reading the chart from right to left, it will be noticed that the normal, light load power is from 2.5 to 5 kw. When the clutch is thrown in, however, the power rises suddenly to about 25 to 30 kw. and drops back with equal suddenness to light load again. At the working stroke the power again rises, this time to about 37 kw., and again drops to normal almost instantly. It is evident that the motor is bearing the full strain of the load. For all practical purposes the flywheel might as well not be there. This is seen from the fact that the input to the motor rises and drops so suddenly. When the load comes on the motor its speed does not drop very much. This is true because the ordinary squirrel-cage motor is practically a "constant-speed" machine and does not slow down markedly with increased load. For this reason the flywheel on the press cannot help much in doing the work over the peak-load period.

Contrast this curve with the one at the right, in which the power demand of a motor with a high-resistance rotor is shown. The total work done is naturally about the same, but it is far more evenly distributed, and therefore the operation is more satisfactory. On throwing in the clutch the speed of the motor decreases

momentarily, thus reducing the shock of engagement. The power demand, instead of rising to 30 kw., rises to about 7 kw. Moreover, on the working stroke the motor again slows down, thus compelling the flywheel to perform its proper function of shouldering the peak load, and so doing its share of work with a striking reduction in power. The motor then rapidly accelerates the flywheel and restores its momentum ready for the next working stroke. Since there is ample time to do this before the next piece of work can be fed into the machine, no disadvantage is involved, and violent strains to the motor and press are avoided. The higher resistance motor used in the test described was made by the Lincoln Electric Company. This company has made a study of such drives and the results obtained from the application of various amounts of resistance in the rotor.

With the lower peak loads which are present with the higher-resistance rotor, there are other advantages. In the first place many power companies object to a rapidly fluctuating load. Sometimes they measure the maximum demand and put on an additional rate corresponding to the magnitude of the demand. Another advantage is that smaller conductors may be used in the motor circuit. This is especially important if the circuit is long and will consequently have a large voltage drop.

Of course this type of motor does not solve every direct-driving problem. The ordinary type of motor is often suitable for direct coupling to the machine it drives. Some factory equipment, such as centrifugal pumps, sandblasters, and so on, starts on comparatively light load, and for these the ordinary motor is quite suitable. Others, such as beaters in paper-mills, require considerable power to start them from rest, but once started the load is fairly constant. For such work the slip-ring type is eminently suitable. But there are many other machines besides presses for which special motor types should be used if the most satisfactory operation is to be obtained.

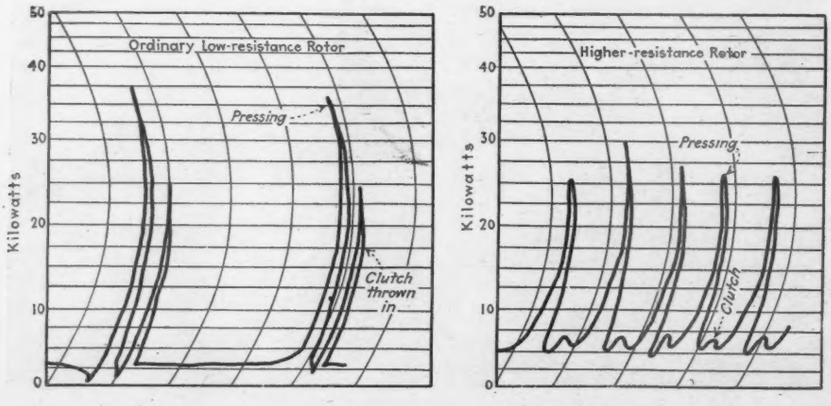
One of the most important uses of these is for elevators, cranes and hoists. In equipment of this nature the low-resistance motor is of little use. Elevator motors—and these are representative more or less of the entire class of units for hoisting work—must be able to start up a load from rest without jerks and jars; they must accelerate steadily; and they must be capable of exerting their maximum torque at the moment of starting (when the load is heaviest). Since the work of an elevator is intermittent, and consists more of starting and stopping than anything else, the limiting of the starting current is far more essential than the theoretical overall efficiency on full load. The elevator type of motor therefore has a still higher rotor resistance than that of the "half-high" torque type used for driving presses.

An important point to be noted is that these special types of motors are not interchangeable as regards the work they will do. Just as the low resistance of the rotor of the ordinary motor renders it useless for elevator work, so the high resistance of the elevator type would cause excessive heating if run continuously on full load even for an hour or two. The selection of the right kind of motor, therefore, to "fit the job" involves a considerable amount of investigation and research.

New York, N. Y. V. D. GREEN.

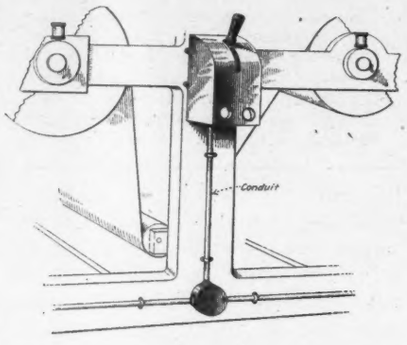
A motor with high rotor resistance is better for direct drive on a press.

The motor in each case is driving a Stohl press making 14-gage, 7-ft. fence posts. The curve at the left is from an induction motor with the ordinary rotor. The motor which gives the curve at the right has higher resistance in its rotor.



Trouble Avoided by Use of a Special Oil-Proof Cable on Machines

THE CONTROL cable used on printing presses is especially liable to damage by the oil which is constantly present around such machines. In this connection the make-up of a small multiple-conductor cable



Printing-press control which employs oil-proof cable.

used by one of the largest printing establishments in the country for the control of large printing presses shows a very interesting development of much practical value.

The cable is run in iron pipe conduit attached to the framework of the press and also passes through junction boxes as shown in the sketch. Oil from the machinery gets into the conduit through the covers of the junction boxes, and it seems impossible to exclude it. This oil naturally causes deterioration of ordinary rubber insulation around the wires. In order to keep the oil away from the rubber insulation the special cable was tried.

Probably the main distinguishing feature of this cable is that two varnished-cambric tapes are wound in opposite directions around the assembled conductors and under the outside overall braid. In the cable there are seven No. 14 American wire gage conductors. Each of these conductors is rubber insulated and wrapped with a dry braid with distinguishing markers. Then the two varnished-cambric tapes are wound in opposite directions around the assembled conductors, and these are followed by an overall saturated braid. This gives an oil-proof cable of a diameter suitable for ¾-in. conduit. This cable has given very satisfactory service and is well adapted to the conditions encountered.

F. A. WESTBROOK.
Field Engineer.
Habirshaw Electric Cable Company, Inc.,
Yonkers, N. Y.

Making Laps for Cemented Endless Leather Belts for Industrial Purposes

IN THE June, 1923, issue of the INDUSTRIAL ENGINEER, on page 309 in connection with the article on "Reclaiming Leather Belts," appeared some information supplied by The Leather Belting Exchange on "Making a Belt Scraper," one of the most important tools for belt work. Here is some additional information on making laps.

The first step is to decide on the length of the lap desired. Generally speaking, it is wise to make a new lap of the same length as the others in the belt, although when joining double belts this may be varied to suit the conditions. One lap should not be made over another lap, and it may be necessary to make a lap longer or shorter to avoid this.

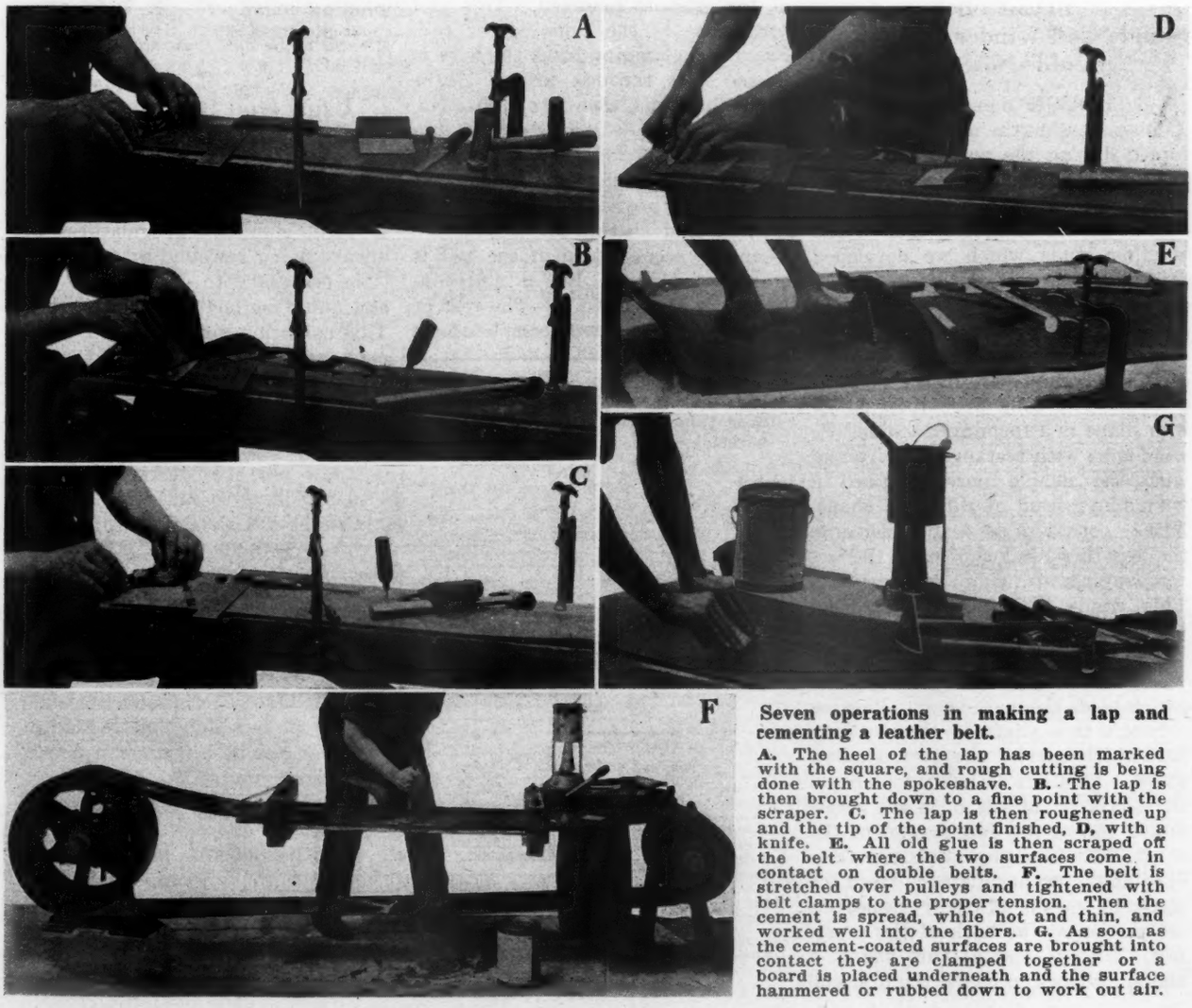
The things to be remembered are that the line of the point and the line of the heel of the beveled edge must be exactly square with the edge of the belt, and that the bevel from heel to point must be uniform and regular, and without "humps," especially back of the point, to prevent the proper adhesion of the cement at every point of contact.

Clamp the belt to the table, so that both hands are free for the use of tools, as is shown in several of the accompanying illustrations. Measure the lap desired, and mark across the belt a line drawn with the use of the square, as representing the end or heel of the lap, and proceed with the spokeshave to cut away the material, from this line down to the end of the belt, the latter becoming the point of the lap. This should be "roughed off" with the spokeshave, and then scraped down to the point with the scraper, and trimmed with a knife, as in D.

A small steel plane also can be used to advantage in connection with the spokeshave. Any man handy with tools can soon learn to make a good lap quickly. The following important points worth noting in connection with the illustrations are:

(*a*) The points of the laps always must be exactly square with the edge of the belt. Guesswork will not do here. (*b*) The lap must be gradually tapered from heel to point. Avoid a hump back of the point. (*c*) Take care to remove all the old glue, and to present a clean, fresh surface to the cement. (*d*) See that the glue is hot, and not too heavy; spread thin, working it carefully into the fibers of the leather. (*e*) Bring the two glued surfaces together, taking care that they do not slip on each other. Rub the joint with a scraper handle to supply a little pressure or place the joint between two small boards and apply pressure with the bench clamps. (*f*) Permit the glue to "set" for an hour, before putting the belt on the pulley.

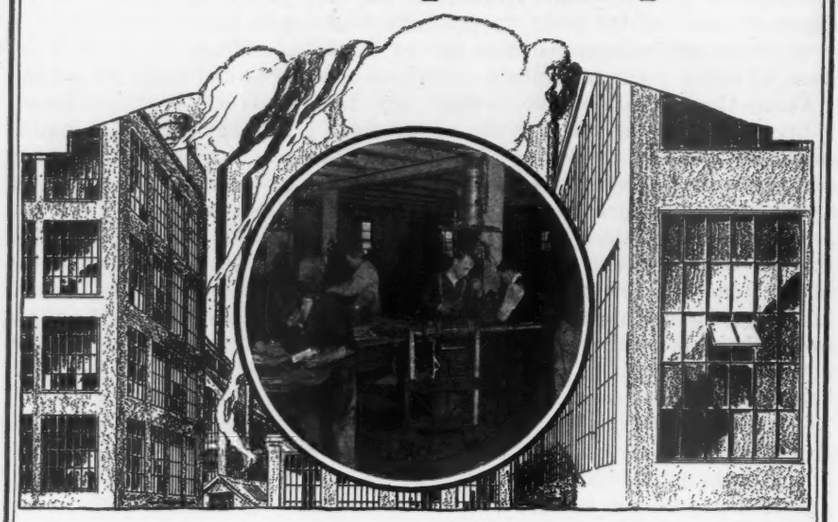
LOUIS W. ARNY.
Secretary
The Leather Belting Exchange,
Philadelphia, Pa.



Seven operations in making a lap and cementing a leather belt.

A. The heel of the lap has been marked with the square, and rough cutting is being done with the spokeshave. **B.** The lap is then brought down to a fine point with the scraper. **C.** The lap is then roughened up and the tip of the point finished, **D,** with a knife. **E.** All old glue is then scraped off the belt where the two surfaces come in contact on double belts. **F.** The belt is stretched over pulleys and tightened with belt clamps to the proper tension. Then the cement is spread, while hot and thin, and worked well into the fibers. **G.** As soon as the cement-coated surfaces are brought into contact they are clamped together or a board is placed underneath and the surface hammered or rubbed down to work out air.

In the Repair Shop



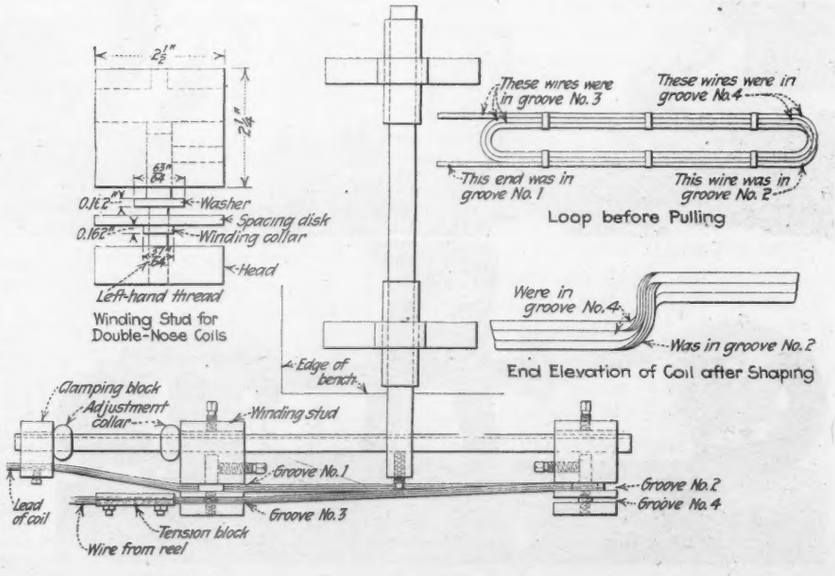
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Repair Shop
Simple Coil Winder for Making Double-Nose Coils

ALTHOUGH there are good coil winders on the market, we were forced during the war to make our own winder. This winder may be interesting to other repair shops on account of its simplicity and of the winding studs which we developed for taking care of the double-nosed coils of rectangular wire. This machine at first was made with a straight winding stud for winding coils with round wire in the form of a loop. The coils were then pulled into shape in a forming machine. To wind coils with rectangular wire and with the double nose required a winding stud of different shape. After considerable experimenting, the winding stud shown in the accompanying drawing was devised. This winds the coils in a perfect manner.

The winder consists of a bearing which is mounted on the bench and which holds the main shaft. Passing through this shaft is the winding bar which carries the two winding studs. This bar is held in place on the shaft by means of a set screw which enters the outside end of the shaft. The winding studs are fastened at the proper distance from the shaft by means of their respective set screws at the back of the cross-bar. On one end of this bar is a clamping-block in which the first end of the wire is fastened. This end forms one of the loops of the coil. From this clamping-block the wire is passed first through groove No. 1 in the first stud, then into groove No. 2. One complete turn is wound into these grooves, holding the tension block as close to the winding block as possible to prevent the wire from turning and cutting the insulation. Then the second turn of the coil is started in groove No. 3 and continued in groove No. 4. The rest of the turns are then completed in grooves 3 and 4. The loop is formed so that the wires fit into each other, as shown in the upper right-hand side of the drawing, and when pulled, the coil will appear as shown in the right hand side of the drawing.

A coil winder with a special winding stud for making the double-nose type of coil with rectangular wires.



The head of the winding stud is clamped with a left-hand screw with three full threads. To remove the coil after it is wound, unscrew the heads from both studs and pull off the coil with the spacing disc and winding-collar. These two are made in one piece so that they are more easily handled while winding coils.

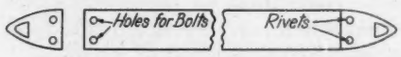
A special winding stud or block must be made for each different kind of coil. The particular block shown in the illustration has dimensions for a coil of three turns of three wires, each wire being 0.039 in. by 0.170 in. and insulated with a double cotton covering. This is the type of coil used in the Westinghouse 10-hp., type S K direct-current motor. For other sizes of wire and for other numbers of turns the dimensions may be different for the washer and the winding collar.

E. T. WALK.
Chief Electrician,
Mineral Point Zinc Company,
Depue, Ill.

Using Iron Band As Sling Facilitates Handling Armatures in Repair Shop

IN A REPAIR shop in which a large number of armatures are always being rewound or overhauled it is necessary to devise some easy and quick method of handling them. This condition obtains in our repair shop, and we have found that a wide sheet-iron band equipped with two eyes large enough to fit the crane hook is often to be preferred to rope

rigging when moving heavy armatures around. As shown in the accompanying illustration, one of the eyes can easily be fastened with bolts and thus made detachable so that the band can be placed on the



The eye at one end is fastened with bolts so as to make it detachable for greater ease in handling.

floor and the armature rolled onto it. This type of band is also useful in removing armatures from small haulage locomotives where the field of the motor is in two parts. It is a simple matter to remove the eye from one end and slip the band around the armature, while it is very inconvenient to handle such an armature with a rope sling.

Comerio Falls, Bayamon, Porto Rico. FREDERICK KRUG.

Importance of Knowing Direction D. C. Motors Rotate Before Overhauling

THE direction in which the brushes are set on a commutator may be no indication of the direction of rotation of the armature because brushes are operated stubbing on one machine and trailing on another. Therefore, when a machine is sent to the repair shop to be overhauled, the direction in which the armature turned "on the job" should be known to the overhauler; otherwise the machine may be released with the shunt and compound windings connected for the wrong direction of rotation of the armature. When the operators find that the rotation is wrong for the work, the chances are that reversal will be effected by reversing the connections of only the shunt winding.

In one instance a 50-hp. motor used on a concrete mixer was sent in to be repaired and overhauled. It was in no condition to be operated, so that the direction of rotation for existing connections could not be determined by trial, and in this particular case a test might have given no helpful indication because the motor as received was wrongly connected. In any event the motor was repaired and overhauled and its series and shunt windings properly connected for clockwise rotation with trailing brushholders. When it was connected to the concrete mixer, the latter was driven in the wrong direction; without any hesitation the operator reversed the direction by reversing the shunt winding, thereby causing the two windings to oppose each other. As the series field was relatively weak, the motor operated with no signs of trouble other than sparking brushes. This did not alarm the operator because it was a condition to which he was accustomed. Later, however, he called for help because the motor could not be started. A troubleman found that failure to start was due to an open circuit in the shunt field circuit and on fixing this the motor started, but with sparking that suggested other trouble. Disconnecting the motor from its mechanical load, the troubleman again interrupted the shunt field circuit and moved the starting box handle around until the motor started on the series winding alone and rotated in the opposite direction. On reconnecting the shunt circuit and reversing the series circuit, the armature started more promptly than before and absolutely without sparking—a condition with which the operator was not familiar.

Brooklyn, N. Y. J. A. HORTON.

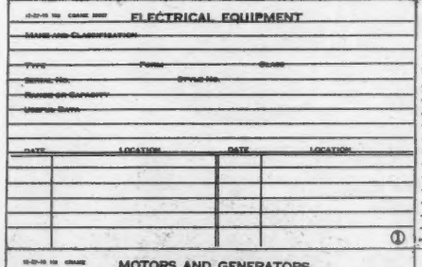
Cards Give Complete Record of Electrical Equipment

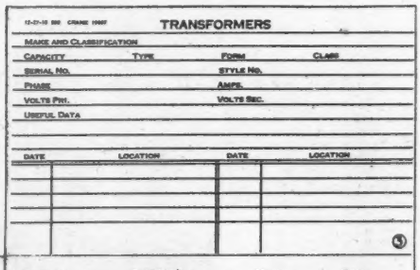
THE four card forms shown in the accompanying illustration have been of much value in systematizing the records of the electrical equipment at the Lowell Mine of the Calumet and Arizona Mining Company. These cards are of uniform size, measuring 3 in. by 5 in., and are of different colors which helps in keeping them in their proper place in the files. On the cards devoted to motors and generators there is a space for the shop number. These are serial numbers which are assigned by the electrical department and stamped on the frames of the machines. Our system of numbering makes it easy to locate the card for any motor or generator, as all of the 2-hp. motors are numbered from 200 to 299, the 3-hp. motors from 300 to 399, and so on. When there are more than 100 machines of any one size, a letter is added after the number, as 200-A, 300-A, etc. The cards are then filed according to the serial numbers. W. R. GIBSON.

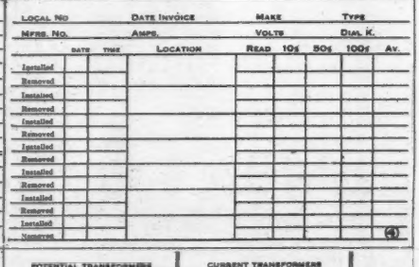
Chief Electrician,
Calumet & Arizona Mining Co.,
Warren, Ariz.

Record cards like these give almost any information desired about equipment in use.

Card 1 is used for starting equipment, controllers, instruments, and so on. Card 4 is used for meters and the reverse side (not shown) furnishes a similar record for potential and current transformers.






LOCAL NO
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Installed
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Installed
Removed
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The first step, if rewinding is necessary, is to strip off the coils, clean commutator and test for short circuits or grounds and clean the iron. Straighten bent punchings and file off any rough surface. Wind the coils on the core, making sure that they wind snugly into the slot, using such winding cells and filling pieces as are necessary to make them tight. Wind the top part of the coils high enough in the slot for the core bands to exert a pressure on the coils when down on the core. Place leads down in an even manner so there will be no crosses in the leads. Use such insulating material as is necessary at points where there may be danger. After putting the top leads down plug the commutator and solder.

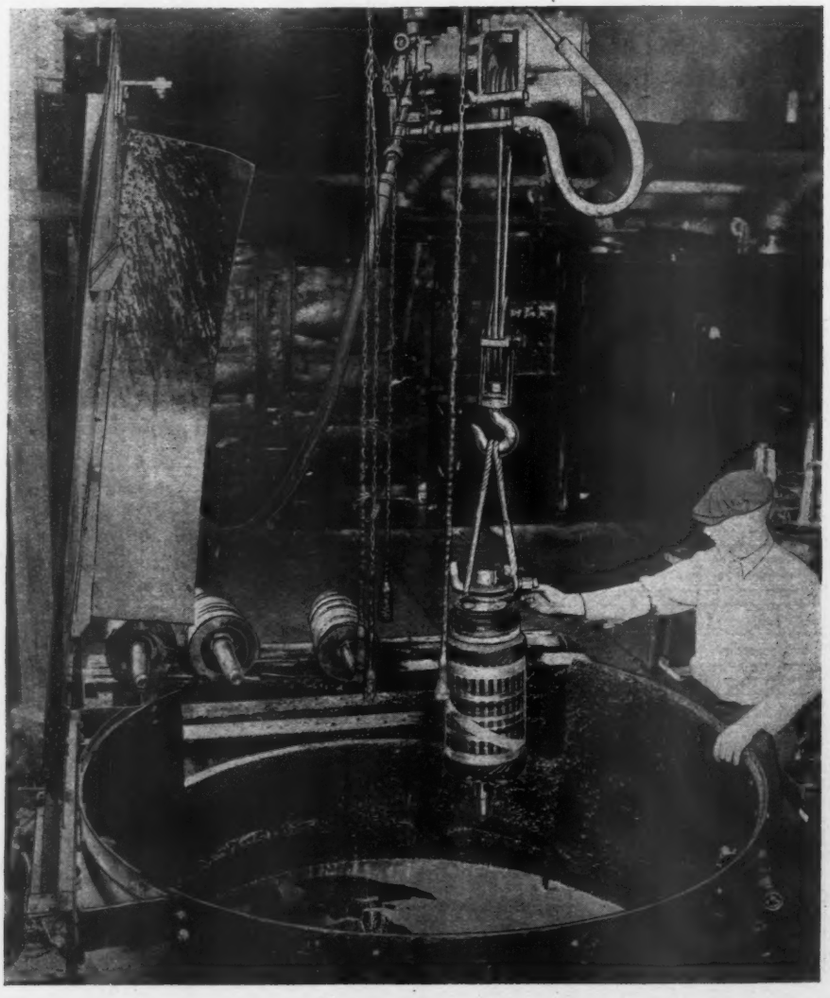
After soldering place the armature in oven for eight or ten hours for heating before banding. If the coils are high and it is thought that it will be difficult to get them down and also have tight bands run on temporary bands. Use material enough under bands to insure that the wire will not damage the winding. Place the bands so that there is no place for the varnish to pocket during dripping and baking.

If no temporary bands are needed, the permanent bands can be placed on the core, and if the armature is baked in a vertical position, the hood and end band that are up during baking can be applied if desired.

Dip and bake the armature according to the method previously outlined. After dipping and baking, turn the commutator and neck and put on the hood, insulation and permanent bands, treating the armature as recommended for overhauled armatures. Finish the completed armature in the same manner as described in the previous article.

The dipping tank should be made of sheet metal (preferably steel) of a thickness sufficient to retain the dipping compound without buckling. It should be made water-tight by welding the edges. Some tanks have been equipped with covers that are released in case of fire by the melting of a fusible wire, thus releasing a latch and dropping the cover automatically, which quickly smothers the flame. When large tanks are used with heavy covers it is somewhat more convenient to make the cover removable altogether. With this type of tank it is advisable to provide a cistern outside of the building, connected to the tank by a pipe line provided with a valve that can be readily opened, in case of fire, thus emptying the dipping compound into the cistern. In connection with the dipping tank it is necessary to provide a suitable rack on which to drain armatures after the dipping process. This can take the form of a rack placed over the tank or built at the side of the tank with a suitable drain connected.

Dipping may be done with the armature in either a horizontal or a vertical position.



Although the practice and recommendation of the Westinghouse Electric & Manufacturing Company is to dip the armatures, a number of operating companies find it more convenient to roll their armatures in a pan or trough. Another type of tank shown in an accompanying illustration is made of sheet metal. An air hoist or a differential chain hoist above the tank is preferable to an electric hoist, since a spark from the electric-hoist motor may be the means of igniting the explosive mixture produced by the benzine vapor.

Two grades of dipping varnish commonly used in connection with the process of dipping and baking armatures are marketed—one with a china wood oil and the other with a linseed oil base. Our company has used both, as either one is suitable for this work. At present we are using a clear varnish, which has a china wood oil base, because it tends to dry out more uniformly and has a less injurious effect on built-up mica parts. The solvent for both of these varnishes is benzine.

Armature baking ovens have been made of wood lined with asbestos. sheet iron, cement or brick, and heated by either steam, hot-air furnaces or electricity. Formerly it was the practice to bake armatures at 257 deg. Fahr., from 24 to 48 hours, depending on the size. Better results are obtained from a lower baking temperature and longer baking time as the danger of taking the life out of the insulation is removed and the varnish bakes more evenly.

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Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Handling Materials

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

An Accident Points Out That Repairs and Doing Without a Magnet for Two Months Cost More Than a New One

THE OLD ADAGE, "We never miss the water 'till the well runs dry," may be truly applied to many concerns which use material-handling equipment in their every-day activities. Here, altogether too often, the benefits resulting from this use are taken as a matter of course and the user never really considers what the equipment is doing until some mishap occurs. It is then, when the substitute equipment must be obtained that the real worth of the installation is emphasized. This, for example, was the case at the Cleveland (Ohio) plant of the Ferro Machine and Foundry Company where approximately a carload of iron is melted each day. This means the handling and rehandling of many tons of material.

For a number of years a locomotive crane with a magnet has done the unloading and other miscellaneous material-handling work around the yard. Recently the magnet, which was of an old design no longer made, gave out completely. When the question of repair arose the manufacturer of the magnet advised the purchase of a new standard magnet of modern design. At first rewinding of the coil and rebuilding the magnet was considered. A careful estimate indicated that these repairs would cost at least $1,000 and require approximately two months to complete because a new pattern would have to be made and a manganese-steel casting made and ground to size. After this the coil would have to be wound. Before deciding to rebuild the magnet the yard boss was called in to help find the cost of doing without the magnet until it could be rebuilt. He estimated that to do the magnet's work by hand would cost at least $20 a day, or for the approximately fifty working days in the two months, about another $1,000.

To do by manual labor the work which this locomotive crane and magnet do, would cost about $20 per day.

After a number of years' service the magnet formerly installed gave out. Estimates showed that it would require about $1,000 to rebuild the magnet and another $1,000 for labor to do its work manually for the two months that would be required for the repairs. A new magnet would cost only approximately $1,500, so $500 was thus saved by the purchase of this Ohio magnet (the Ohio Electric & Controller Company, Cleveland, Ohio) and two months of trouble were avoided.

In this way, rebuilding the old magnet would cost about $2,000 and it would still be an old magnet without any guarantee as to its useful life, its capacity, or its effectiveness in the work. On the other hand, a new magnet would cost less than $1,500 and be covered by an absolute guarantee for one year and in addition be of modern design with greater lifting capacity and a useful life expectation of from fifteen to twenty years. With these figures in hand, it was decided at once to purchase a new magnet and effect an economy of $500 as well as eliminate a good deal of trouble and a lack of assurance that the rebuilt magnet would stand up in service for a satisfactory length of time.

Reclaiming Coal By Loading Trucks Mechanically Instead of by Hand

THE RECLAMATION of coal from yard storage, when this is done manually, usually requires the entire time of two or three men. However, if mechanical means of loading and carrying are utilized, the same amount of work can usually be done in a much shorter time. At the industrial plant shown in the accompanying illustration, a Link-Belt portable belt conveyor (Link-Belt Company, Chicago, Ill.), is shown loading a truck. This conveyor has a capacity of 45 cu. ft. of coal a minute, which will load a motor truck in a few minutes. The big saving here, in addition to the fact that the two men who load the portable belt conveyor can do their work in much less time, is in the decrease in waiting time of the truck, as probably it would take a half hour or more to load this truck by hand. A similar time-saving advantage is gained when conveyors are used to load electric industrial trucks fitted with dump bodies, or to pile coal.

In addition to handling coal, any other loose material such as sand, stone, gravel, fertilizer, foundry refuse, debris, and similar material which is ordinarily loaded by hand shovelers, may be moved by this type of conveyor much more economically and easily and in less time. Other types of this machine may be

A motor truck can be loaded with coal in a few minutes with this portable belt conveyor.

One of the big items of economical operation of motor trucks is to decrease the loading and unloading time to a minimum. Here the truck is loaded in a few minutes by this portable belt loader, where it would require possibly a half hour or more for two men to load it with shovels.

obtained with longer belts for higher piling or for transferring longer distances. Frequently two or more of these conveyors are placed in series—one feeding the next—and so used to carry material some distance either in piling or reclaiming. This 18-in. conveyor belt is operated at a speed of 250 ft. per min. by a 2-hp. motor mounted in the base.

Cutting Costs on Moving and Piling Material With a Tiering Machine

MATERIAL HANDLING consists usually of a group of operations such as picking up, loading, carrying, unloading or piling and returning for a new load. It is almost impossible to eliminate any of these operations but savings can be made by shortening the time of doing any of them or by increasing the load handled with the same or less effort. In the studying of any material-handling problem it always pays to investigate the operations which require more than the ordinary effort, especially those which require extra men.

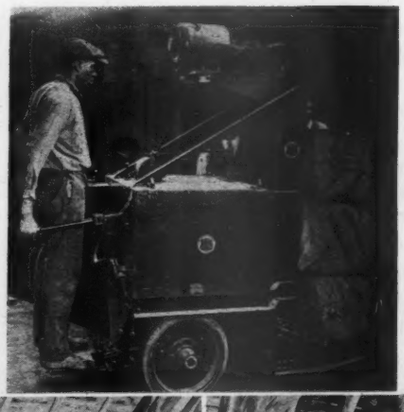
One of the most conspicuous examples of this is in piling, as carrying and unloading of most articles might be performed by the trucker. When piling, however, especially if the object is heavy and must be raised to some height, the operation may require several extra men. In such cases savings may be made in various ways, such as by the use of conveyors, elevators, piling machines or other methods of doing the work. Usually these not only decrease the cost per unit but also increase the quantity moved in the same time.

At the Appalachian Corporation at New Orleans, La., for example, heavy bags of cottonseed oil meal have to be hauled about 180 ft. and piled to the ceiling, as shown at the left in the accompanying illustration. With the four-wheeled trucks shown, six bags were hauled at a trip and six men were required to pile them. If the pile was higher it would take two more men for the next tier. The cost here was 58 cents per ton.

When a Lakewood tier-lift electric truck (The Lakewood Engineering Company, Cleveland, Ohio) was used only three men were required—one on the truck and two on the pile—a reduction of half the force

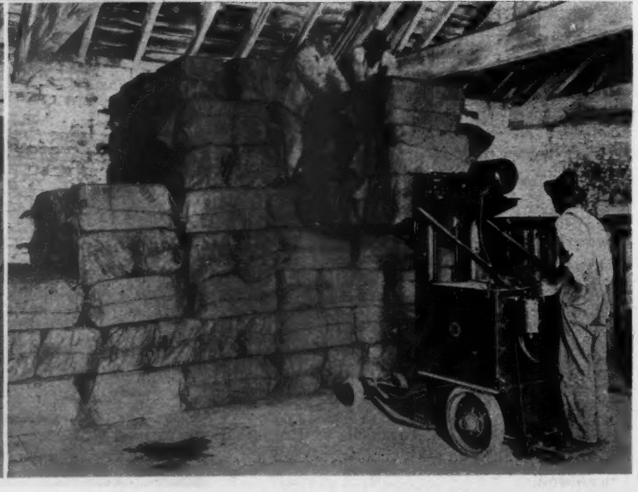
In addition, the tier-lift truck will go into the car to get its load, as shown in the smaller illustration. The length of the haul remained the same, 180 ft., after the tier-lift truck was installed as when hand trucks were used. The cost of handling with the new equipment was only 15 cents per ton. The cost of the electric energy was about 40 cents per day. In addition to this reduction of 74 per cent in the cost of handling, about 88 per cent more cottonseed oil meal was handled by the three men in a day then was possible before.

These savings were made possible by larger loads per trip, higher speed per trip both when loaded and empty, and a saving in the time and number of men required for piling. An analysis of almost any material-handling job indicates savings which may be made if only the proper equipment is applied to it. All that is required is a knowledge of what the equipment will do and what is necessary to be done.



This tier-lift truck not only reduced the cost of handling and piling these bags 74 per cent but also increased the output 88 per cent with half the force.

The tier-lift truck is driven and the load raised and lowered by electric motors which are supplied with power by storage batteries carried in the truck. Here the amount of the load was increased 50 per cent and the working force was decreased 50 per cent, with the result that 88 per cent more material was handled in a day at a cost of 15 cents per ton, compared with a previous cost of 58 cents per ton. In addition, this truck can be used as advantageously for taking material from the pile as for piling it.



Directions for Making Motor Tests

(Continued from page 334)

is used to supply the corresponding current coil of the wattmeter, as shown in Figs. 4 and 5. In other words the current coil and potential coil must be in the same phase. In addition the currents in the current coil and in the potential coil must be in proper relative direction to insure correct operation of the meter. Connection diagrams are always furnished with recording wattmeters by the maker, but even if these are lost the meter may be connected correctly by following a simple rule. First make sure that the current and potential coils in one element of the meter connect to the same phase. Then reverse either the current or the potential leads for either side (or element) of the meter until a positive reading is secured from each of the two elements. In making these connections by trial it must be remembered that the power factor of the load must be 50 per cent or over in order to secure a positive reading on each of the two elements. After the correct connection is found by this method a diagram is made and followed for any other loads.

In order to make testing easier it has been the writer's method when installing compensators and motors to connect the leads from the starting compensator to the leads running to the motor by means of a brass sleeve wire connector shown in Fig. 5. The wires are held in this connector by means of four screws. In making motor tests where the drive may be shut down for five minutes the current transformer loop may be inserted after opening up two of these leads, as in Fig. 4. The third wire connector is untaped and the middle potential lead is attached by a battery clip.

After the connections are made it is good policy to tape up the exposed wire ends and connectors. Before starting the motor the current transformers should each be short-circuited on the secondary side, to prevent the heavy starting current from throwing the meter pointers off scale. Some current transformers have short-circuiting switches which may be used for this purpose. Where there is no such switch a piece of flexible wire may be wrapped around the binding posts. After the motor has started the short is removed. If, however, it is desired to measure the starting current, no short circuiting is necessary. The transformer in this case, though, must be of such a ratio that the starting current will not damage the meter.

In case it is impossible to shut down a drive long enough to insert the testing leads, a current-tap lug such as that furnished by the States Company has been used by the writer as shown in Fig. 5. One of these lugs to which is attached a current-transformer lead, is clamped to the bare wire on either side of the wire connectors. Then the wire connector is opened and the current flows around the opening through the current transformer. On voltages below 550 there is little danger if the electrician is careful and wears rubber gloves and stands on a dry board.

A Case Where a Motor Test Was Valuable

An illustration of using the motor test to detect the cause of an overload on a motor is afforded by the accompanying motor-test records, Nos. 673 and 674, shown in Fig. 2 and the corresponding meter charts in Fig. 6. In test No. 673 the no-load input to the motor indicated 26.8 hp. when there was no water flowing through the pump. The average load when pumping with clear water or a mixture of water and cinders was 165.2 hp. From the data you will note that the driving motor is rated at 75 hp. which was ample for driving the pump at full load under normal conditions. After the motor had been running abnormally hot, test No. 673 was made to determine the nature and amount of the overloading. As the load on the pump was not affected by the quantity of cinders handled with the water, it was evident that the excessive load was caused by some mechanical defect in the drive. The covering over the pump was dismantled and in dismantling the pump it was found that one of the flanged couplings next to the pump had become loose on the shaft, thus allowing the unbalanced water pressure against the impeller to force the impeller against the pump casing. The thrust bearing for this pump was located on the side opposite the loose coupling. After a new coupling had been put on the pump shaft the drive was assembled and test No. 674 was then made which showed an input to the motor of 70.5 hp., on the average.

A somewhat similar example was shown in tests on a double-reduction-geared coal-mine hoist. The motor, which was of the slip-ring type, had been giving trouble and it had burned off several jumpers on the rotor bars. When the first test was made it was found that the load of one empty cage going up was higher than that of the other empty cage when going up. As the hoist was of balanced construction this condition, of course, should not have existed. A thorough inspection of the drive was then made and it was found that the brake band which had recently been relined did not have sufficient clearance when released. The brake was of the contracting-band type and the tendency was to grab more firmly when running in one direction than when running in the other. After the release mechanism had been changed to give a greater clearance to the brake band the load was reduced almost one-half for both starting and running.

Distribution and Chord Factors

(Continued from page 355)

are wound full pitch or whose sides lie in slots 1 and 7. It will be noted from the arrowheads on the coil sides showing the direction of the current at a given instant, that the center line of one pole lies between slots 6 and 7, and that the arrowheads for both tops and bottoms of slots are in exact symmetry on either side of this center line. Comparing Fig. 11, which shows a similar winding except that the coils are chorded and wound in slots 1 and 5, it will be seen that the center line of a pole now lies between slots 5 and 6, and another between slots 11 and 12. The arrows in slots 5 and 6 and 11 and 12 are in opposite directions, and hence the effect of the winding in these slots cancels out. If the shape of the magnetic field form in the two cases of Fig. 9 and Fig. 11 be plotted out by the well known "stair step" method,* it will be found that the shape of the resulting field from the winding in Fig. 11 is flatter on top and not quite so nearly a sine curve shape as would be the field resulting from the winding shown in Fig. 9. From this comparison can be drawn directly the fact that the *chord factor*, which depends on the throw of the coil, is different for the windings shown in

*See Dudley's "Connecting Induction Motors," published by McGraw-Hill Book Company.

Figs. 9 and 11, but the *distribution factors* are the same. On the other hand, comparing Figs. 9 and 10, the *chord factors* of these two windings are the same because the coils have the same throw but the *distribution factors* are different, as explained in connection with Fig. 6.

From the foregoing discussion it may be seen that the *distribution factor* is a measure of how efficiently the turns in the winding are used. In other words, a direct-current field coil, as illustrated in Fig. 1, makes 100 per cent use of the turns, whereas a single-phase winding as shown in diagram *B* of Fig. 3 only uses them 63.6 per cent efficiently. Again the effectiveness of the turns is a measure of the possible output, either in the form of electrical energy as in a generator, or mechanical energy as in a motor, from a given weight of copper, so that all things being considered, that connection should be used which will give the highest possible *distribution factor*.

Material Moves With Production

(Continued from page 347)

rolled by hand over onto the other flange which is then straightened by the second bulldozer on the other side of the machine, thus allowing two poles to be in process at the same time.

The poles, resting on rollers, are then pushed off the straightening machine back across the cooling chains and sent through a brushing machine. This consists of a number of rapidly revolving steel brushes. On the first pass through the machine one side of the pole is thoroughly brushed to remove all loose scale and dirt. The second pass, whereby the other side of the pole is brushed, is made in the opposite direction and through the other side of the machine. The poles are thus returned to the cooling chains and after traveling a short distance are picked up by a floor-operated 2-ton Shepard hoist and immersed for about a minute in a long narrow tank containing paint. The paint is kept at a temperature of 140 deg. F. by means of steam coils and the temperature of the poles when they are dipped is about 200 deg. F. As a result the paint is baked on the poles, which are dry a few minutes after they are removed from the tank and placed on the discharge table.

The chemical composition, particularly the carbon content, of the metal in the beams is closely controlled with the result that very few defective poles are produced. Further, the act of expanding is sufficient to reveal all hidden defects. Imperfections are, of course, easily seen and poles which are not perfect are removed from the cooling chains and put aside before being painted.

The lacings are cut from the flanges of defective poles by means of the oxy-acetylene torch and the flanges are then used to make base extensions or splice plates for poles. On the whole there is so little waste produced in the manufacture of poles that it requires several years to accumulate a carload of scrap.

After the paint is dry the poles are carried by a 3-ton cage-operated Shepard monorail hoist to finished storage or loaded directly into cars for shipment. For ocean and also for less-than-carload shipments the poles are fastened together by special clips in bundles of three poles each. In order to facilitate the loading of cars, two outgoing tracks are available: one through the building, a comparatively short distance from the paint-drying table, and another which runs close to the wall, outside of the building. The monorail track, on which travels the hoist for dipping the poles in the paint tank, extends the length of the building and over the outdoor loading track. On this overhead track there are three monorail hoists, one floor- and two cage-operated, so that cars on the two outgoing tracks can, if desired, be loaded simultaneously from both finished storage and directly from the paint-drying table.

From the layout of the plant, shown in one of the accompanying illustrations, it will be seen that the material in process does not at any time back-track: the movement is continuously forward from the time the beams, the raw material, are unloaded from the cars, until the poles, the finished product, are placed in finished storage, or loaded on the cars for shipment.

In the process of manufacture there are twelve operations, as follows: (1) Unload beams and put in storage; (2) take beams from storage to shear; (3) shear and punch holes; (4) take beams from shear to storage; (5) take beams from storage to furnace; (6) take beams from furnace to expander; (7) expand; (8) take expanded beam, or pole, to cooling chains; (9) straighten; (10) brush; (11) dip in paint; (12) load poles in cars, or take to storage. Of these operations, expanding takes the most time and is used as the base for timing. Two minutes are allowed for this operation, although it has been done in somewhat less time, and an occasional check is made to see that this schedule is maintained. If the time required averages much more than two minutes an investigation is made to determine the cause. The operator of the expanding machine thus sets the pace for the entire plant and, inasmuch as all of the operations are so closely connected, any lagging either before or after the expanding operation is easily detected. Maximum output under present conditions is thus obtained with a minimum of supervision.

Types and Kinds of Chain Drives

(Continued from page 339)

removed occasionally, of course, more frequently in a dusty location, the case cleaned out and refilled with new oil. Improper lubrication is one of the most common forms of neglect of chain drives.

Acording to one manufacturer of silent chains the best method of lubricating a chain drive is to enclose it in a sheet metal casing and permit the chain to operate in a bath of oil. Such a casing to retain oil must have welded joints or be of pressed steel and requires some method of enclosing the openings around the shafts, such as by felt or leather washers. These casings are usually made in upper and lower halves and should be reinforced around the edges with angle-iron and the upper half allowed to extend down into the lower half about 2 in. Such an installation will lengthen the life of a chain drive from 50 to 100 per cent and is advisable on most chain-drive installations and necessary on installations where the speed is high. There is, however, a large number of installations where such a method of lubrication is not absolutely necessary and in these cases lubrication should be provided by oiling not less than every other day. Nothing but a light lubricating oil should be used and of the best quality obtainable. Cheap oils and heavy greases tend to form gum on the links and prevent lubricant from reaching the joints. Oil should be applied to the inside of

the chain while running so that the centrifugal force will tend to throw the oil out to the pins. As soon as oil begins to appear on the back of the chain it is an indication that sufficient lubrication is on the chain for the time being.

Another manufacturer recommends the following method of lubricating roller chain drives. Clean the chain thoroughly in a bath of gasoline or kerosene and then completely immerse it in hot, liquid graphite grease, and leave it in until it has become as hot as the grease. Otherwise, the grease merely chills on the surface of the chain and does not penetrate. For the best results, it is desirable to heat the chain itself before putting into the graphite bath.

After removing the chain from the bath, place it on a level surface and push the links together so as to take up all the stress, thus permitting the lubricant to become settled in the bearing. When the chain is cold, wipe it off well on the outside before placing in service to prevent the excess lubricant gathering dust and grit. The use of stick graphite is not recommended because it merely places the graphite on the outside of the chain and so silences it slightly without removing the cause of the noise or working into and lubricating the wearing parts. It also gathers dust which works into the chain and causes excessive wear.

The frequency of lubrication depends entirely upon the purpose for which the drive is used. This method of lubricating a chain is recommended as secondary to operation when immersed in oil. Experience has shown that a chain properly cared for and run in oil has lasted six or seven times as long as a chain operated under similar duty on an exposed drive.

Another article in a later issue will take up other points on the selection of chains, their application and their use and abuse in service.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the article which is to follow on this subject: American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.

Practical Books
For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

E M F Electrical Year Book—Edited by F. H. Bernhard, second edition, published by Electrical Trade Publishing Company, Chicago, Ill., 1,230 pages, illustrated. Price, $10.

This Year Book is a combined dictionary, encyclopedia and trade directory covering the electrical industry, with all topics arranged alphabetically. Practically every electrical and closely allied product is listed, defined and followed by a complete list of its manufacturers; every trade name used by the industry is also listed and information given about the product it relates to, together with the name of the manufacturer. In addition, every manufacturer is listed separately by company name and information is given about the office, product made and location of district offices. There are also thousands of additional entries covering the definitions of all electrical words and terms, historical and statistical information about electrical applications and activities, biographical sketches of prominent scientists and engineers, and information about electrical associations, schools, colleges, patents, exports, and many other allied subjects. All of this information is likewise compiled alphabetically.

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Electric Transients—By C. E. Magnusson, A. Kahn and J. R. Tolmie. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. First edition, 190 pages. Price, $2.50.

The increasing size and complexity of electrical systems and apparatus are making necessary a closer study of transient electric phenomena, those changes which take place in a system with changes of load. Those who are interested in such phenomena will find much to interest them in this book which is based on an introductory lecture and laboratory course that has been given for some years to electrical engineering students in the University of Washington. The purpose of the book is to give a clear conception of the fundamental principles of electric transient phenomena and their application to quantitative problems. In keeping with the elementary treatment of the subject the first chapters are devoted to the definition of, and formulas for, the properties of electric, dielectric and magnetic circuits. Chapter two deals with oscillographs, describing the types which are on the market, with wiring diagrams and directions for taking oscillograms. Other chapter headings are: single energy transients, direct currents; single energy transients, alternating currents; double energy transients; electric line oscillations; surges and traveling waves; variable circuit constants; resonance; oscillograms. The text is liberally illustrated and supplemented by a large number of oscillograms of transients that occur in the various types of machines and electric circuits in common use in electrical engineering laboratories. In an appendix there are given directions on the technique of developing and printing oscillograms.

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Metals and Their Alloys—By Charles Vickers, published by Henry Carey Baird and Company, Inc., 2 West Forty-fifth Street, New York City, 800 pages. Price, $7.50.

The author, a well-known authority, has prepared a thoroughly practical book which is partly based on Wm. T. Brannt's "Metallic Alloys." It contains a description of the best American practices in dealing with metals and their alloys and takes up the chemical as well as the physical properties and many of the applications of alloys in various industries. Included in this is information on the various alloys of aluminum and the proportions to be used for different purposes as well as a chapter on die casting, die casting methods, machines and applications.

The alloys have been placed in twelve distinctive groups, according to the metal used as base, and are as follows: (1) aluminum alloys, (2) bronzes, (3) brasses, (4) nickel alloys, (5) tin alloys, (6) lead alloys, (7) amalgams, (8) alloys of the precious metals, (9) fusible alloys, (10) iron alloys, (11) magnesium alloys, (12) zinc alloys.

Those working with alloys can use this not only as a guide, but also as a reference work for there are included hundreds of tables giving the composition, properties and analysis of alloys of every description and for almost every purpose.

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Plastic and Moulded Electrical Insulation—By Emile Hemming, President, American Insulator Corporation. Published by The Chemical Catalogue Company, 19 East 24th Street, New York, N. Y. 313 pages, illustrated.

There are in existence burned clay objects estimated to be 10,000 years old and which may be taken as evidence that the manufacture of ceramic products is one of the very oldest industries. In this book, which is one of the few, if not the only treatise on the subject, the author discusses in considerable detail the properties, manufacture and method of forming plastic materials into the desired shapes. It is an interesting story and it is told in such manner that the layman will find it easy to read and understand, while the expert will come across much valuable information. The book is divided into two sections. The subjects covered in the various chapters of the first part are: ceramic products, including the raw materials and

the method of manufacturing and coloring ceramic ware; calcareous cements and artificial stones, mortar, cement, concrete and plaster; glass, its history and manufacture, raw materials and manipulation; casein products, origin and uses; plastics in road construction, foundations, road repairs and pavements; sundry patent references, covering a number of compositions of varied character.

The second section of the book is devoted to molded insulation and comprises six chapters, as follows: history of molded insulation; raw materials; classification, hot-molded, cold-molded, ceramics, rubber compounds, and so on; molds and dies; selection of materials; properties and relative characteristics.

An especially valuable feature is the inclusion at the end of each chapter of a list of the patents issued, and the points covered, on the subjects treated therein.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

E. C. Atkins and Company, Indianapolis, Ind.—A unique piece of literature distributed by this company contains the Constitution of the United States of America, with the Amendments and Reference to the Bill of Rights. The foundations of our Republic rest on the principles outlined in the Constitution and in many quarters these are being undermined. This may be overcome to a large extent by a wider knowledge of the provisions of our Constitution. For this reason the company has gone to the expense of publishing the Constitution in handy pamphlet form free from advertising. A copy will be mailed to any individual interested.

The Surty Manufacturing Company, Inc., 4131 West Kinzie Street, Chicago, Ill.—A folder describes the Surty belt handler which is used to remove and replace belt on machines such as punch presses where it is desirable to remove the belt for safety while setting the die. With this equipment it is claimed that a belt can be removed or replaced in three seconds. The folder also describes a shifting device for the automatic shifting of cone-pulley belts.

Benjamin Electric Manufacturing Company, 847 West Jackson Boulevard, Chicago, Ill.—A small folder describing the Benjamin-Starrett dead-front standardized panel boards describes and lists the different features embodied in them. These are listed in capacities of four to thirty circuits and are furnished with tumble, push or knife switches.

The Gellman Wrench Corporation, Rock Island, Ill.—A folder describes the Gellman "Polly" quick-adjusting wrench. It is made in three sizes, 6-in., 9-in. and 12-in. with corresponding jaw openings up to $\frac{11}{16}$ in., 1 in., and $1\frac{7}{16}$ in.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio.—Literature on the new "Imperial Undercutter" gives some of the unusual features of this slotting machine, such as that it is driven through a 4 ft. flexible shaft from an electric drill and therefore may be purchased with or without the motor; it has a movable block with guide for riding in an adjacent slot; it has a micrometer screw adjustment to set the saw in the exact center of the mica; compressed-air line may be attached to blow the dust away from in front of the cutter; "V"-shaped milling cutters are used instead of square saws to give a "V"-shaped slot.

Jewell Belting Company, Hartford, Conn.—A small booklet entitled, "Useful Information Concerning Belts and Their Application," gives in condensed form a large amount of information on measuring belts, finding the velocity of the belt, how to order belting, suggestions for the care and operation of belts, determining the horsepower and other subjects.

Birdsboro Steel Foundry and Machine Company, Birdsboro, Berks County, Pa.—A booklet describes the Jackson belt lacer. This is a special hinged joint made by a machine which laces a coil of wire through each end of the belt. The coil is then flattened out, the two ends of the belt put together and joined by a pin. One feature of this booklet is a chart illustrating, numbering and listing the parts of the belt lacing machine to facilitate ordering repairs. In addition several pages are devoted to pulley and belting data.

Western Electric Company, 195 Broadway, New York City—Publication 23021 describes the "Tork Clocks" which are used for turning electric lights on and off regularly. A phantom view shows the details of construction and operation of this clock. This is made in three sizes for 6 amp. 125 volts, 15 amp. 250 volts, or 30 amp. 250 volts.

Thermalene Gas Corporation, Kankakee, Ill.—A folder describes the "Thermalene Ideal Goggles" which are of a new design so arranged that they are held away from the face and are hinged so that the lenses may be raised between cutting or welding periods when examining the work, thus making it unnecessary to remove the goggles from the face.

The Cleveland Crane & Engineering Company, Wickliffe, Ohio—A loose-leaf catalog No. 2 describes the various uses and applications of the Cleveland Electric Tramrail. This takes up illustrations and descriptions of various installations in foundries, warehouses and other plants, as well as hand and electric carriers, cranes and transfer bridges, attachments, fittings, and numerous suggestions for applications and installations. A number of pages is devoted to the practical information which would be needed for the installation as well as for laying out of equipment of this sort.

Roller-Smith Company, 233 Broadway, New York City—Bulletin 250 describes the Roller-Smith Portable Direct Current Galvanometers, types LGD and KGD for use where sensitive but very rugged devices are wanted.

Victor Balata and Textile Belting Company, 48 Murray Street, New York City—A booklet entitled, "How to Figure Belts," gives a number of rules, tables and other data for determining the correct drive for various kinds of belts. Two special features are the pages devoted to "Helpful Hints" and to the transmission card showing the information desired or needed when selecting a belt for particularly unusual service conditions. Other folders describe each of the various types and grades of stitched canvas and Balata beltings manufactured.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A small folder lists prices and describes the "Efficiency" refillable plug fuses. These are made in capacities of 6, 10, 15, 20 and 30 amp., 125 volts. These are so constructed that the refillable section for a 20 amp. fuse, for example, cannot be seated in a plug rated at 10 amp.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis.—A 58-page booklet is devoted to centrifugal pumps and motor-driven centrifugal pumping units. Numerous tables and other engineering data as well as a complete description of the equipment and illustrations of a number of installations are included.

American Spiral Pipe Works, Chicago, Ill.—Catalog 22 describes and illustrates the construction and many of the applications of Taylor spiral riveted pressure pipe. Some space is devoted to special steel fittings and to engineering data on the flow of water through pipes and other useful information.

The Bryant Electric Company, Bridgeport, Conn.—A number of revised loose-leaf catalog pages have been recently issued which supersede pages previously issued. Those having catalogs can in this way keep their catalog up-to-date.

The Stanley Belting Corporation, 32-40 South Clinton Street, Chicago, Ill.—A 16-page booklet on the Stanley solid-woven cotton belting illustrates and describes the special features and particular applications to which Stanley solid-woven cotton belting is well adapted. One page is devoted to a discussion of the various types of fasteners recommended for use in connecting this belting.

Bussmann Manufacturing Company, St. Louis, Mo.—A booklet entitled, "The New Knife Blade Type Renewable Fuse," describes and illustrates construction and operating details of a knife blade type of renewable fuse.